MFRC

Midwest Forensics Resource Center

Research and Development Program Summary

October 2008

Acknowledgement

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Midwest Forensics Resource Center (MFRC)
Research and Development Program

Introduction

The mission of the MFRC Research and Development Program is to provide technological advances in forensic science for the benefit of our regional partners as well as the forensic community at large. Key areas of forensic science need are identified through our interactions with our Midwest partners and our R&D advisory group, as well as through our participation in national meetings in forensic science. Under the sponsorship of the National Institute of Justice and the U.S. Department of Justice COPS Program, the MFRC solicits proposals for the development of practical and useful technology, instrumentation, and methodology that address needs in areas related to forensic science and its application to operational crime laboratories. The MFRC facilitates proposal development by working to establish partnerships between researchers and our regional partners. The MFRC administers a peer-review of the proposals and then funds the selected projects at a cost of approximately $55,000 each, with a 12-month period of performance.

The process for selection of these projects includes the following steps: 1) drafting of a call for proposals by MFRC staff, 2) review of the draft call by members of the R&D advisory committee, 3) review and approval of the call by NIJ, 4) issuance of the call to ISU, Ames Laboratory, regional partners, and research organizations, 5) receipt of proposals, 6) review of proposals by R&D advisory committee, 7) ranking and selection by MFRC staff using advisory committee reviews, with concurrence by NIJ, 8) notification of proposers, 9) receipt and review of progress reports by MFRC, 10) receipt and review of final reports by MFRC, R&D advisory committee, and NIJ.

The decision to fund any specific project is based upon a peer-reviewed call-for-proposal system administered by the MFRC. The reviewers are crime laboratory specialists and scientists who are asked to rate the proposals on four criteria areas including: 1) relevance to the mission of the MFRC, 2) technical approach and procedures, 3) capabilities, teaming, and leveraging, and 4) dissemination and implementation plan. A successful proposal demonstrates knowledge of the background for the research and related work in the field and includes a research plan with a defined plan to implement the technology to benefit our partners at the crime laboratories.

Program Summary Technical Sheets

The following project summaries, while not a complete summary of all research areas, are meant to demonstrate the range of research funded by the MFRC. The project summaries describe the forensic need the projects serve as well as the benefits derived from the technology. The summaries provide a brief description of the technology and the accomplishments to date. In addition, the collaboration with regional partners and the status of the dissemination of project results and implementation of the product are highlighted. These technical summaries represent the development and implementation of practical and useful technology for crime laboratories that the MFRC hopes to accomplish.

TABLE of CONTENTS

Abstracts of Funded Projects

CHEMISTRY

- ***Analysis of Automotive Clear Coat Paints by Micro-Laser Raman Spectroscopy*.** Jay Siegel, School of Science, Indiana University – Purdue University, Indianapolis (IUPUI), Indianapolis, Indiana.

  This project partially funds the purchase of a micro-laser Raman spectrometer to evaluate the feasibility and discriminating power of Raman spectrometry in the characterization and analysis of automotive clear coat paints. This represents one phase of an ongoing project in the analysis of clear coats undertaken by the Forensic and Investigative Sciences Program at IUPUI. The methods used include micro-laser Raman spectroscopy, Fourier transform infrared spectrophotometry and UV-visible-near infrared spectrophotometry. The Raman phase of the project is conducted in partnership with the Indiana State Police Forensic Science Lab.

- ***Determination of Heavy Metals in Whole Blood Using Inductively Coupled Plasma – Mass Spectrometry.*** Joseph Wermeling, Wisconsin State Crime Laboratory-Madison, Madison, Wisconsin and Charles Cornett, Department of Chemistry and Engineering Physics, University of Wisconsin – Platteville, Platteville, Wisconsin.

  The forensic investigation of toxicological cases involving acute intoxication, poisoning, and death is heavily focused on the analysis of organic and pharmaceutical analytes of interest. The determination of inorganic analytes, especially heavy metals, is often limited to a few metals. Tools used include relatively insensitive wet chemical techniques or single-element methods employing atomic absorption or graphite furnace methods. This project addresses the need for the development of rapid, sensitive, multi-elemental methods for the analysis of metal toxins in whole blood, thereby expanding the range of inorganic analysis in toxicological investigations.

- ***Application of Chemometric Procedures to Differentiate Ignitable Liquid Residues from Substrate Interferences*.** Ruth Waddell-Smith, School of Criminal Justice, Michigan State University, East Lansing, Michigan.

  In arson investigations, fire debris is typically extracted and analyzed to determine the presence of ignitable liquid residues. Yet, identification of these residues can be complicated by interferences from substrates. This project targets development of an objective methodology for differentiating ignitable liquids from burned substrates by creating reference collections. The project also demonstrates the potential of statistical and chemometric procedures to associate and differentiate classes of liquids and to differentiate liquids from burned substrate interferences.

- ***Evaluation of a Portable Raman Analyzer for Testing Drugs.*** Susan Gross, Minnesota Department of Public Safety, Bureau of Criminal Apprehension, St. Paul, Minnesota.

  Large case backlogs can cause slowdowns and delays in the judicial system. Speedy trial demands by the defendant are difficult to maintain with these backlogs. This project evaluates a portable drug identification system, using laser-based Raman technology, to ease some of the backlog problems. The evaluation of the Raman StreetLab® is performed in the laboratory and in the field. By implementing a plan to analyze controlled substances in the field, the laboratory case backlog can be alleviated and the prosecution of controlled substance cases can continue in a timely manner.

- ***Fast Gas Chromatography Capabilities in Arson Debris Analysis.*** Charles Cornett, Department of Chemistry and Engineering Physics, University of Wisconsin – Platteville, Platteville, Wisconsin.

  This project assesses the potentially large impact that fast gas chromatography (Fast GC) may have on the determination of ignitable liquids. *Forensic Sciences: Review of Status and Needs* clearly defines a need for further advances in this field. In addition, current analytical literature appears to support Fast GC as a separation technique capable of comparable resolution to conventional GC in less time per sample. This research compares resolution capabilities of the two techniques in separating a wide range of ignitable liquids in an array of matrices. With sufficient resolution, Fast GC may help clear casework in a more timely manner.

- ***Micromechanical Cantilever Based Sensors for Chemical Species Detection.*** Pranav Shrotriya, Department of Mechanical Engineering, Iowa State University and Marit Nilsen-Hamilton, Department of Biochemistry, Biophysics and Molecular Biology, Iowa State University, Ames, Iowa.

  The merging of silicon microfabrication techniques with surface functionalization biochemistry offers opportunities for developing microscopic analytical devices with unique characteristics. This project develops a proof-of-concept for high specificity and sensitivity micromechanical cantilever-based (MC) sensors. Successful completion of the research may help the development of portable sensors capable of detecting chemical species at concentrations of parts-per-billion. Such sensitivity will revolutionize forensic analysis of controlled substances, explosives, biological molecules, and DNA required for crime-scene investigation.

- ***Optimization of HeadSpace - Solid Phase Microextraction for Organic Impurity Profiling of Illicit MDMA Tablets.*** Ruth Waddell, Department of Chemistry, Michigan State University, East Lansing, Michigan.

  Organic impurity profiling of illicit synthetic drug tablets aims to identify similarities among tablets. Similar impurity profiles indicate a common production method, and similar levels of the same impurities potentially indicate common production

laboratories. In this research project, headspace solid phase micro-extraction (HS-SPME) procedures for the extraction of organic impurities from illicit MDMA ('ecstasy') tablets are developed and compared with conventional liquid-liquid extraction procedures, in terms of the number and level of impurities extracted. HS-SPME is rapid, requiring no solvent and yielding selective extraction of impurities. Hence, HS-SPME is a promising extraction procedure that offers attractive advantages over conventional procedures.

- ***The Temporal Fate of Drugs in Decomposing Tissues.*** John Wyman, Franklin County Coroner's Office, Columbus, Ohio.

  Interpreting drug concentrations found in decomposed remains is always difficult. Postmortem tissues that are routinely collected and analyzed (blood, urine, vitreous humor), and therefore provide the largest comparative database for interpretation, are frequently lost in the early stages of putrefaction. Consequently, when drugs are found in weathered tissues, there is currently little or no information available to help guide the toxicologist, and subsequently the pathologist, in evaluating whether a drug(s) played any significant role in causing the death. This study follows the fate of sixteen drugs, which commonly cause intoxications, in seven different tissues collected from decomposing pigs.

- ***Ultra-Fast Gradient Elution HPLC as a High Throughput, High Information Content Screening Tool for Drugs of Abuse.*** Peter Carr, Department of Chemistry, University of Minnesota, Minneapolis, Minnesota.

  This project is a continuation of previously funded work titled "Ultra-Fast Gradient Elution Reverse-Phased HPLC with Diode-Array Detection." That activity improved both the speed and selectivity of older HPLC methods through a combination of precise retention measurements and chemometric analysis of the spectro-chromatograms. In the currently funded two projects, several enhancements are examined. First, to improve selectivity, three HPLC phases are studied to find the pair that is most orthogonal so as to dramatically reduce the number of indistinguishable analytes. Second, to improve speed, recently commercialized very small stationary phases that use the "core-shell" concept are applied. Finally, the sensitivity and specificity of the new methodology is studied by evaluating real samples whose compositions have been pre-assessed by accepted confirmatory methods, especially LC-MS.

DIGITAL EVIDENCE

- ***A Steganalyzer Package for Forensic Applications***. Jennifer Davidson, Department of Mathematics / Electrical Engineering, Iowa State University, Ames, Iowa.

  The use of steganographic software for hiding information in image files for illicit purposes is becoming more widespread. While steganalysis algorithms are abound in the academic literature, there are few software programs that address the needs of localpolice departments who perform computer forensic functions for steganalysis. This

project extends the proof-of-concept established on the use of an artificial neural network for wavelet steganalysis in an earlier study. Specific aims are to enhance the capabilities of the software and to make it available for practical use in computer forensics.

PATTERNED EVIDENCE

- ***Application of Crystal Orientation Method to Forensic Physical Matching of Metal Surfaces along a Fracture Line.*** Barbara Lograsso, School of Technology, Michigan Technological University, Houghton, Michigan; Thomas Lograsso, Ames Laboratory, Iowa State University, Ames, Iowa; and James Kreiser, Springfield, Illinois.

  A physical match between two surfaces is routinely viewed as definitive proof that the fracture surfaces were generated from the same part. The practice of fracture matching has recently been challenged in court. Therefore, there is a need for a method to measure the nature and characteristics of materials with a known error rate that can be applied to performing physical matches. This study examines the feasibility of using surface crystal orientation to associate or differentiate metal fracture fragments found at crime scenes.

- ***High Speed Digital Video Analysis of Bloodstain Pattern Formation from Common Bloodletting Mechanisms.*** Terry Laber, Minnesota Department of Public Safety, Bureau of Criminal Apprehension, St. Paul, Minnesota; Bart Epstein, Edina, Minnesota; and Michael Taylor, Institute of Environmental Science and Research, Christchurch, New Zealand.

  The analysis of bloodstain patterns is used by criminal investigators to draw inferences about the events that led to the formation of the pattern. An understanding of the dynamics of a blood transfer event is therefore critical to the sound interpretation of the resultant bloodstain pattern. This project studies the formation of some common bloodstain patterns by using a high-speed digital video camera to record the blood transfer as it occurs. The outcome of the research will strengthen the science behind bloodstain pattern analysis (BPA).

- ***CD-ROM Based Digital Information Database on Pipe and Tubing Utilized in Improvised Explosive Devices.*** Jamie Crippin, Western Forensic Law Enforcement Training Center, Pueblo, Colorado; David Green, Lake County Crime Laboratory, Painesville, Ohio; and Will Randle, Missouri State Highway Patrol Laboratory, Jefferson City, Missouri.

  The rise in terrorist bombings has made the identification of bomb materials a priority for the forensic scientist. The volume of evidence to be analyzed and the importance of such testing for preventive and investigative purposes have created a need for reliable, fast, and cost-effective tools that can help identify specific tubing material used for bombs. The objective of this project is to collect data on all known types of pipes and tubing and to store the information in a searchable CD-ROM-based database. Such a

database greatly reduces the amount of time and effort spent by forensic scientists to process bomb samples.

- ***Quantification of the Individual Characteristics of Human Dentition.*** Thomas Johnson, School of Dentistry, Marquette University, Milwaukee, Wisconsin.

  Although DNA can be associated with a human bite, it is not always recovered. In such cases, an analysis of bitemark evidence is required. Yet, forensic odontologists are under attack for lacking a scientific basis for their analysis. This project studies the ability to scientifically quantify the occurrence of special dental characteristics and error rates in the analysis of bitemarks. Using six measurements, a 3D quantification technique and 400 samples, a database is created that may provide the criminal justice system with the beginning of a tool and the hard science for objective statement of probability, in either exculpating or incriminating a suspect from patterned injuries cause by human teeth.

- ***Spectral Analysis of the 3D Fracture Surfaces for Enhanced Matching.*** Ashraf Bastawros, Department of Aerospace Engineering, Iowa State University, Ames, Iowa; Barbara Lograsso, School of Technology, Michigan Technological University, Houghton, Michigan; and Jeremiah Morris, Johnson County, Sheriff's Office Criminalistics Laboratory, Mission, Kansas.

  A fractal surface carries sets of unique signatures dictated by the intrinsic material microstructure and the external loading conditions. This project combines the basic understanding of fracture mechanics with the practical applications of forensic science to develop testing protocols for improved matching of fractured surfaces. A 3D spectral analysis of the fracture surface is developed to identify these fracture signatures and to show their uniqueness for each fractured specimen. Fracture of metal coupon specimens are used to generate proof-of-concept and to establish the feasibility of the approach. The matching ability is then compared against the techniques currently used in forensic labs.

- ***A Method for Lifting Bloody Impressions Using a Lifting Strip Containing Titanium Dioxide.*** Jessica Zarate, Northville City Police Department, Northville, Michigan.

  Bloody impressions are of great importance to the forensic community as they are frequently encountered at crime scenes. Impression evidence in blood cannot always be removed from the crime scene for analysis in a laboratory setting. Because of this, many potentially identifiable impressions can only be photographed and not enhanced, thereby complicating the latent print identification process. In an earlier study, a lifting strip containing titanium dioxide was successful in lifting and enhancing bloody fingerprints from several non-porous and semi-porous surfaces of contrasting colors. This study improves upon the methods used to lift bloody palm prints, foot prints, and footwear impressions, in addition to bloody fingerprints from porous, semi-porous, and non-porous surfaces.

- ***Testing for Potential Contextual Bias during the Verification Stage of the ACE-V Methodology when Conducting Latent Print Examinations.*** Glenn Langenburg, Minnesota Department of Public Safety, Bureau of Criminal Apprehension, St. Paul, Minnesota.

  Recent Daubert challenges to fingerprint evidence and the ACE-V methodology have questioned the reliability of the methodology as it is currently applied by experts. This project studies the potential effect of contextual bias on expert opinion. Experiments were conducted at an International Association for Identification conference in Boston, MA, and at a local community college where the principal investigator teaches an introductory course in forensic science. The results of the experiments provide valuable insight on the effects of potentially-biasing context information, when present, during the verification of latent print examinations.

BIOLOGY/DNA

- ***Testing DNA Samples for Population of Origin.*** Raymond Miller, School of Medicine, Washington University, St. Louis, Missouri.

  This activity funds the development and implementation of a forensic test to help field investigators with unidentified DNA samples and to provide information about the population of origin of the donor of the DNA sample. The test uses available equipments to genotype ancestry informative single nucleotide polymorphisms (SNPs). The results will be compared with known population frequencies of self-described ethnic groups to narrow the possible ancestry of the sample.

Analysis of Automotive Clear Coat Paints by Micro-Laser Raman Spectroscopy

FORENSIC TECHNOLOGY NEED

Little attention to date has been paid to clear coats. This may be due, in part, to the lack of inorganics in clear coats, which are almost always present in color or base coats. Recent advances in micro-laser Raman instrumentation make it easier to obtain high quality spectra of small materials, like the cross section of a chip of automotive paint.

TECHNOLOGY DESCRIPTION

Micro-laser Raman spectroscopy is a very powerful sampling and analysis technique that acquires spectra of extremely small areas non-destructively and without touching the sample. Although widely used in many different fields, the technique has seen little application by forensic scientists.

The main objective of this research is to evaluate the effectiveness of micro-laser Raman spectroscopy in discriminating among automobile clear coat paints.

A secondary objective is to evaluate micro-laser Raman spectroscopy as a part of a scheme to analyze automotive clear coats. Other techniques that are used in such a scheme are also evaluated. They include Fourier Transform Infrared (FTIR) spectrophometry and Ultraviolet (UV)-Visible-Near Infrared (NIR) spectrophotometry.

METHODOLOGY

To achieve these objectives, a micro-laser Raman spectrometer will be purchased to evaluate the feasibility and discriminating power of Raman spectrometry in the characterization and analysis of clear coats.

Specific activities include:

- evaluation of micro-laser Raman spectroscopy and optimization of sampling and analysis of techniques.
- partial validation of the techniques and proposed scheme.
- use of the scheme that is developed

ACCOMPLISHMENTS AND ONGOING WORK

A laser Raman spectrometer was purchaed for the analysis of clear coats. The instrument was defective and replaced by a CRAIC, model CTR-1, 2.5 MW laser at 785 nm.

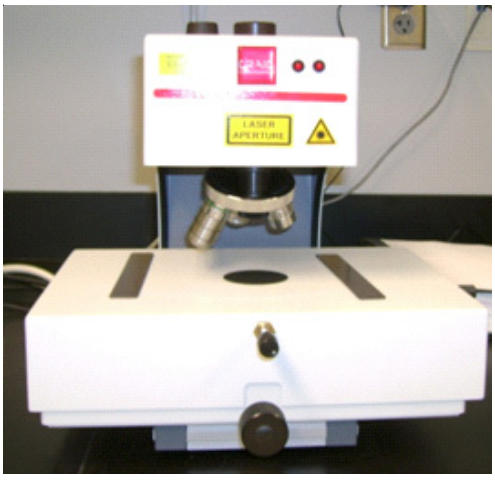

Figure 1. 2.5 mw, 785 nm microlaser Raman with 20x objective

More than 200 samples of automobile paint chips with make and model information were obtained and a method for sectioning the chips was developed. Paint chips were tested under several thickness conditions

(whole chip, 15 µ, 10 µ,and 5 µ). It was found that 5 µ cross sections generated the clearest Raman spectra.

Spectra of different clear coats were collected using both 50x and 20x objective lenses. Data revealed that spectra obtained from 50x objective were no better than those from the 20x objective, yet they took longer to collect.

The PI is currently working on optimizing the integration time and number of averages necessary to obtain the best Raman spectrum for the clear coats. Based on parameters tested, integration has been narrowed to between 20 and 60 seconds, and number of averages between 5 and 10.

TECHNOLOGY BENEFITS

Clear coats on automobile paints are very common today. Yet, they have not been analyzed forensically to any degree. This project shows the value of laser Raman spectroscopy when applied to the analysis of trace evidence. Use of the instrument will improve the scientific value of paint evidence and increase the association value of paint evidence to a suspect source.

COLLABORATION

The research is conducted by the Forensic and Investigative Sciences Program at Indiana University, Purdue University, Indianapolis (IUPUI). The Raman phase of the project is conducted in partnership with the Indiana State Police Forensic Science Laboratory.

Using IUPUI blind samples and samples from previous casework, forensic scientists from the Indiana State Police (ISP) use their own FTIR and UV-Visible-NIR instrument as well as the Raman instrument to evaluate paint chips. They will also determine the effectiveness of the scheme and of Micro-laser Raman, in particular, to characterize and compare known and unknown paint chips.

The ISP will further prepare a number of proficiency tests to use for further validation of the Raman technique and of the scheme.

DISSEMINATION

The findings of the research will be presented at the 2009 America Academy of Forensic Science meeting in Denver, CO. A paper will also be prepared for submittal to the Journal of Forensic Sciences, while a final technical report on the project and its findings will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

This is a new project with no publications or presentations to date.

IMPLEMENTATION

ISP will use the scheme (developed form this research) in the analysis of case samples of paint as they come into the lab, and as a supplement to their normal analysis protocols. They will have use of the Raman instrument and microtome for their case work.

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Determination of Heavy Metals in Whole Blood Using Inductively Coupled Plasma - Mass Spectrometry

FORENSIC TECHNOLOGY NEED

The forensic investigation of toxicological cases involving acute intoxication, poisoning, and death investigations is heavily focused on the analysis of organic and pharmaceutical analytes of interest.

The determination of inorganic analytes, especially heavy metals, is often limited to a few metals, using relatively insensitive wet chemical techniques or single-element methods employing atomic absorption or graphite furnace methods. Because these methods are limited and time-consuming, testing for toxic metals in blood samples often goes undone.

TECHNOLOGY DESCRIPTION

The primary objective of this project is to employ the sensitivity, wide dynamic range, and multi-element capabilities of inductively coupled plasma mass spectrometry (ICP-MS) to the elemental analysis of samples related to forensic toxicology.

Specific goals of the project are to:

- develop a rapid screening method for heavy metal toxins using the semi-quantitative feature of ICP-MS
- develop and validate a quantitative method for arsenic, cadmium, mercury, thallium, and lead in whole blood
- asses the use of microwave-assisted digestion of whole blood samples in addition to currently used dilution protocols

METHODOLOGY

This project addresses the need for the development of rapid, sensitive, multi elemental methods for analyzing metal toxins in whole blood.Two different approaches are used in establishing the methods.

First, the diluents for several well-established biomonitoring procedures are evaluated for both semi-quantitative and quantitative analyses.

Second, the use of microwave-assisted acid digestion of whole blood samples is evaluated. Such digestion procedures have been shown to remove effects from dissolved solids and the carbonaceous components of biological samples. Optimization of both dilution and digestion is carried out in an interactive fashion.

ACCOMPLISHMENTS AND ONGOING WORK

Two separate methods for the determination of metals in blood were developed. The first method employs microwave digestion of whole blood samples in HNO_3 / H_2O_2, followed by matrix-matched standard additions analysis in the ICP-MS. The second method involved direct analysis of whole blood following dilution with a diluent, also employing matrix-matched standard additions analysis.

Both methods were linear (R^2=0.999) over the ranges calibrated. Arsenic was calibrated from 10-250 µg/L, cadmium and thallium were calibrated from 1-10 µg/L,

mercury was calibrated from 1-100 µg/L, and lead was calibrated from 10-250 µg/L. The lower limit of calibration for mercury was changed to 3 µg/L later in the study.

DL (ug/L)	Microwave Method	Dilution Method
As	1.3	5.2
Cd	0.3	1.9*
Hg	1.3	4.6*
Tl	0.6*	0.4
Pb	2.1	4.4

Table 1. Detection limits for five heavy metals utilizing microwave and dilution methods.

The detection limit (DL) for each element was calculated blanks as the mean blank signal plus three times the background. In some cases (*) the DL exceeded the limit of quantification (LOQ) as estimated by the deviation in the low bench standard. The general trend was for lower DLs in the microwave method compared to the dilution method. This was somewhat expected given fewer matrix issues with the microwave digestion method.

^{111}Cd	Accepted Value (µg/L)	Microwave Method (µg/L)	Dilution Method (µg/L)
Low Bench QC	2.0 ± N/A	# 1.77 ± 0.17 (9)	1.6 ± 0.5 (4)
Medium Bench QC	5.0 ± N/A	4.8 ± 0.2 (9)	4.8 ± 0.6 (4)
High Bench QC	8.0 ± N/A	7.7 ± 0.4 (9)	7.9 ± 0.6 (4)
QMEQAS07B-06	14.0 ± 1.1	*12.8 ± 0.8 (5)	12.8 ± 2.5 (4)
QMEQAS06B-08	2.0 ± 0.3	2.6 ± 0.7 (2)	*1.60 ± 0.17 (1)
QMEQAS07B-03	1.31 ± 0.28	*0.9 ± 0.3 (2)	*0.90 ± 0.25 (1)

Table 2. The 95% confidence intervals of the microwave and dilution methods.

Analysis of the medium and high bench quality control standards exhibited very good accuracy for both the dilution and microwave digestion methods. However, the microwave method consistently provided statistically significant ($p < .05$) better precision (RSD from 2 to 10%) than the dilution method (RSD from 8 to 45%). The bulk of the accuracy data for the microwave method falls within 15% of the true value or within 20% near the LOQ.

TECHNOLOGY BENEFITS

With this procedure, toxicology samples can be screened for common heavy metals and for a suite of toxic elements in a single analysis. This ability to routinely test biological samples for a broad spectrum of elemental toxins adds a valuable dimension to forensic toxicological analysis.

Since this project represents collaboration between the toxicology and trace evidence units at the crime laboratory, this work can expand ICP-MS capabilities to other disciplines in the forensic sciences, particularly in trace evidence.

COLLABORATION

This project is a collaborative effort between the Wisconsin State Crime Laboratory-Madison (WSCL-M) and the University of Wisconsin-Platteville. It also represents collaboration between the Trace Evidence and Toxicology Units within the WSCL-M.

DISSEMINATION

The project and its findings were presented as a poster session at the Midwestern Association of Forensic Scientists. The work was also presented at the annual America Academy of Forensic Science meeting as part of the Young Forensic Scientist forum. Further dissemination plans include presentations at the Midwestern Association of Forensic Scientists Fall Meeting and at the Annual

Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy (Pittcon). A final technical report on the project and its findings will also be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Schweitzer, L., Wermeling, J., Cornett, C. "Determination of Heavy Metals in Whole Blood Using Inductively Coupled Plasma Mass Spectrometry: A Comparison of Microwave and Dilution Techniques." Presentation at the Midwestern Association of Forensic Scientists Fall Meeting, October 2007, Traverse City, MI.

- Schweitzer, L., Wermeling, J., Cornett, C. "Determination of Heavy Metals in Whole Blood Using Inductively Coupled Plasma Mass Spectrometry: A Comparison of Microwave and Dilution Techniques." America Academy of Forensic Sciences 60th Annual Meeting, February 2008, Washington, D.C.

- Wermeling, J., Cornett, C., Schweitzer, L. "Determination of Heavy Metals in Whole Blood Using Inductively Coupled Plasma - Mass Spectrometry: Dilution and Microwave Digestion Compared." Oral presentation at the 37th Annual Midwestern Association of Forensic Scientist Meeting, October 2008, Des Moines, IA.

- Schweitzer, L., Wermeling, J., Cornett, C."Determination of Heavy Metals in Whole Blood Using Inductively - Coupled Plasma-Mass Spectrometry." Manuscript submitted to the 60th Annual Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy (Pittcon), March 2009, Chicago, IL.

IMPLEMENTATION

Following instrument overhaul, this work will continue on an unfunded basis. Under the aegis of the WSCL-M Toxicology Unit, acquired data from this project will be used to develop an inorganic database. When completed, the blood metal analysis methods will be added to the WSCL-M Toxicology Unit Procedure Manual.

Also, based on a request from a submitting agency, a protocol for the analysis of arsenic, selecium, cadmium, thallium, and lead in water and clear beverages was developed using the basic outline of the blood methods. This request resulted in a case report. The technique will now be considered as a routine offering of the WSCL-Trace Unit.

CONTACTS

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Application of Chemometric Procedures to Differentiate Ignitable Liquid Residues from Substrate Interferences

FORENSIC TECHNOLOGY NEED

In arson investigations, fire debris is typically extracted and analyzed to determine the presence of ignitable liquid residues (ILR). Identification of these ILRs can be complicated by interference from substrates, such as inherent hydrocarbons and pyrolysis products, making identification of the ILRs difficult and potentially subjective.

TECHNOLOGY DESCRIPTION

The primary objective of this research is to develop an objective methodology for differentiating ignitable liquids from burned substrates. This is achieved by creating reference collections and by demonstrating the potential of statistical and chemometric procedures to associate and differentiate not only classes of liquids but also to differentiate liquids from burned substrate interferences.

METHODOLOGY

Specific goals of the research are to:

- create reference collections of neat and evaporated ignitable liquids
- create reference collections of burned household substrates
- optimize data pre-treatment procedures for statistical and chemometric analyses
- assess correlations among neat ignitable liquids, evaporated liquids, and burned substrates using Pearson product moment correlation (PPMC) coefficients
- assess association and discrimination of neat ignitable liquids, evaporated liquids and burned substrates using principal component analysis (PCA)

ACCOMPLISHMENTS AND ONGOING WORK

This is a new project that has not started work yet.

TECHNOLOGY BENEFITS

Reference collections for burned substrates are not currently available. The creation of a reference collection of burned household items will improve forensic arson investigations. Also, by developing mathematical procedures, subjectivity associated with the comparison of chromatograms will be improved and objective distinction of ignitable liquids from substrate interferences increased. This will reduce the risk of false positive identifications of liquids in fire debris.

COLLABORATION

This is a collaborative effort between Michigan State University and the Michigan State Police. Troy Ernst, of the Trace Evidence Unit of Michigan State Police – Grand Rapids Forensic Laboratory, will serve as consultant on the development of the methodologies and their implications to forensics crime laboratories.

DISSEMINATION

The results of this study will be disseminated through presentations at forensic science conferences, including the

Midwestern Association of Forensic Scientists, and through submittal of a manuscript for publication in the Journal of Forensic Sciences. The project and its results will also be posted on the MFRC web site in the form of a technical report.

PUBLICATIONS AND PRESENTATIONS

This is a new research project with no publications or presentations to date.

IMPLEMENTATION

DVDs of completed reference collections will be created and made available to forensic crime laboratories.

Based on the success of this research, the PIs may seek funding from the NIJ to continue the research.

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Evaluation of a Portable Raman Analyzer for Testing Drugs

FORENSIC TECHNOLOGY NEED

Numerous liquid samples from clandestine laboratories are submitted for analysis. These analyses are very time consuming and oftentimes result in case backlogs. Such case backlogs cause slowdowns and delays in the judicial system. Speedy trial demands are therefore difficult to maintain.

This research project attempts to ease some of the backlog problems by evaluating a portable drug identification system using laser-based Raman technology. The portable Raman system will be evaluated for ease of use and for its ability to analyze controlled substances.

TECHNOLOGY DESCRIPTION

A screening test (non-confirmatory) is often all that is needed to begin the process of prosecuting individuals with controlled substances. Having a portable Raman unit in the field should expedite this process. The Raman is a portable system that can identify controlled substances.

Figure 1. Portable Raman Analyzer Manufactured by Ahura Scientific.

METHODOLOGY

This project does not intend to repeat the already published studies, but to further investigate the analysis of controlled substances utilizing the portable Raman analyzer. Specific types of samples for this project include known standards, liquid samples from clandestine laboratories, tablets, powders, and other street drugs that law enforcement personnel encounter.

ACCOMPLISHMENTS AND ONGOING WORK

Ahura Scientific (the manufacturer of the Portable Raman instrument) provided training in operation and use of the analyzer. They also provided training in how to run the samples and how to incorporate them into a searchable Bureau of Criminal Apprehension (BCA) library.

So far, 200 samples have been run on the instrument and incorporated into the library. Approximately 200 new vials will be purchased, as cleaning the vials is time consuming and cross-examination is an issue. These samples will also be incorporated into the library.

TECHNOLOGY BENEFITS

By implementing a plan to analyze controlled substances in the field, the laboratory case backlog can be alleviated and the prosecution of controlled substance cases can continue in a timely manner. Law enforcement personnel trained on the equipment can obtain results within minutes, thereby making it possible to analyze samples while the suspect is still in custody. Portable Raman analyzers for testing

drugs have the potential to become as commonly used as the Breath Test Units for determining blood alcohol levels.

COLLABORATION

The laboratory portion of this project took place in the Drug Chemistry Section of the Minnesota BCA in St. Paul, Minnesota. Available drug standards were utilized for analyzing known samples. Some previously in the laboratory analyzed "street" samples were also used.

The field portion of this project will take place in the Law Enforcement Center (LEC) in Rochester, Minnesota. The LEC houses various law enforcement agencies including field offices for the BCA and the Gang Strike Force. The Southeast Minnesota Drug Task Force, the Rochester Police Department, and the Olmsted County Sheriff's Office are also located in the LEC.

DISSEMINATION

The results of this research project were presented to BCA agents and were also shared with other law enforcement personnel. The BCA hosts several training classes including a Clandestine Methamphetamine Lab Certification Course and a Drug Investigation Class.

Research findings will further be shared with the manufacturer and be presented at the fall meeting of the Midwestern Association of Forensic Scientists. Upon completion of this project, a manuscript will be submitted to a scientific journal for publication, while a final technical report on the project and its findings will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Gross, S. "First Defender Grant Project." Presentation to BCA agents, January 2008, St. Paul, MN.

- Gross, S. "First Defender Grant Project." Presentation to Minnesota law enforcement agents, February 2008, St. Paul, MN.

- Engebretson, A., Patterson, M., Radthke, J. "Validation Study of the First Defender." Oral presentation at the 37th Annual Midwestern Association of Forensic Scientist Meeting, October 2008, Des Moines, IA.

IMPLEMENTATION

The instrument is currently being used by local law enforcement in the Rochester area of Minnesota. Special agents are testing the instrument by running unidentified substances and liquids from a methamphetamine lab. In the future, the instrument will be offered to other counties to increase the number of scans performed on street drugs.

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Fast Gas Chromatography Capabilities in Arson Debris Analysis

TECHNOLOGY NEED

While autosamplers have increased sample throughput in trace units across the nation's crime laboratories, many laboratories still find themselves needing more throughput.

As defined in *Forensic Sciences: Review of Status and Needs* (NIJ/OLES, 1999). There is a need for method development in the recovery of ignitable liquid residues from a variety of matrices.

TECHNOLOGY DESCRIPTION

Current analytical literature identifies Fast Gas Chromatography (Fast GC) as a separation technique capable of increasing the sample throughput of trace element groups.

The goal of this project is to assess the merit of Fast GC in the determination of ignitable liquids in a variety of matrices. The stable, rapid heating cycle of Fast GC coupled with narrower capillary columns and high phase ratio potentially results in more plates per meter. This increase will enable fast separations with potentially superior resolution compared to conventional GC if hydrogen replaces helium as the carrier gas.

METHODOLOGY

This project tests the hypothesis that Fast GC is a beneficial technique in the area of ignitable liquids analysis. The experimental design uses both solid phase microextraction (SPME) and traditional activated charcoal strip (ACS) to pre-concentrate single compound ignitable liquids (i.e. toluene) and common ignitable liquids These volatiles are analyzed by both conventional GC (helium mobile phase) and Fast GC. The results are statistically compared to test the hypothesis that Fast GC with hydrogen mobile phase provides much faster separation and higher resolution than conventional GC.

ACCOMPLISHMENTS AND ONGOING WORK

Data from this study illustrated that Fast GC alone reduces chromatographic retention times by 60% in the analysis of ignitable liquids. The study also demonstrated that the gains in resolution by switching from helium to hydrogen as a carrier gas (mobile phase) far exceeded the resolution losses from the shorter Fast GC minbore column.

The combination of these approaches (Fast GC and hydrogen carrier gas) produced phenomenal improvements in the analysis of ignitable liquids as the 60% reduction in retention times is accompanied by increases in resolution of up to 500%.

These improvements in separation by Fast GC (hydrogen) compared with conventional GC (helium) were consistently observed in a vast variety of ignitable liquid analyses as well as analysis of ignitable liquids recovered from controlled burn matrices such as asphalt shingles, carpet, carpet padding, and softwood lumber.

Yet, there is a need for serious safety procedures if hydrogen is used as a carrier gas in a gas chromatography-mass spectrometer, rather than the gas chromatography-flame ionization detector (FID) system in this study.

Compound Class	Retention Time (min) (Fast GC)	Retention Time (min) (Conventional)
C4-alkylbenzene	3.93#	10.69#
C4-alkylbenzene	4.14	11.28
C4-alkylbenzene	4.16	11.37
C5-alkylbenzene	4.29	11.74
C5-alkylbenzene	4.36	11.95
C5-alkylbenzene	4.44	12.16
C5-alkylbenzene	4.49	12.32
naphthalene	4.57	12.58
C5-alkylbenzene	4.65	12.77
C5-alkylbenzene	4.70	12.93
C5-alkylbenzene	4.76	13.09
C5-alkylbenzene	4.86	13.39
C1-naphthalene (2-methylnaphthalene)	4.95	13.64
C1-naphthalene (1-methylnaphthalene)	5.04	13.91
C2-naphthalene	5.21	14.43
C2-naphthalene	5.31	14.70

Table 1. Statistical comparison of Fast GC and conventional GC retention times for the separation of 95% evaporated gasoline.

Fast GC analysis of primary standards and samples in dilute CS2 will be completed in the near future and final statistical data comparisons will be conducted. SPME work will extend the library and comparison as far as possible in the remaining time period. This will be followed by analyzing the impact of Fast GC on a practicing laboratory.

Meritorious results will be used to asses the feasibility of and seek out funding related to projects addressing the need for portable instruments and technologies in detecting compounds of interest in arson debris.

TECHNOLOGY BENEFITS

The practical significance of this work for crime laboratories is two-fold: 1) a potential increase in sample throughput and 2) an improved detection of potential ignitable liquids through better resolution.

COLLABORATION

This project is a collaborative effort between the University of Wisconsin-Platteville (UWP) and the Wisconsin State Crime Laboratory-Madison. The principal investigator supervises undergraduate researchers and experiments performed at UWP using the FGC-FID/ECD (Electron Capture Detector), while the co-principal investigator supervises students using the GC-MS at WSCL-M and lends expertise in the area of arson residue sampling.

DISSEMINATION

Initial research data and findings were presented at the Midwestern Association of Forensic Scientists Fall Meeting, September 2007, in Traverse City, MI. Final results will be presented at Pitcon 2009. The project and its research results will also be disseminated in a final technical report posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Cornett, C., Wermeling, J. “Advances in Ignitable Liquid Identification: A Comparison of Fast and Conventional Gas Chromatography.” Presentation at the Midwestern Association of Forensic Scientists Annual Meeting, September 2007, Traverse City, MI.

- Halligan, A., Selle, A., McCrary, C., Jacobs, J., Larsen, L., Vircks, K., Vyhnanek, A., Wermeling, J., Cornett, C. “Fast Gas Chromatography Capabilities in Arson Debris Analyis”. American Academy of Forensic Sciences 60th Annual Meeting, February 2008, Washington, D.C.

- Cornett, C., Wermeling, J. “Fast Gas Chromatography in Arson Debris Analysis.” To be presented at the 60th

Annual Pittsburgh Conference and Exposition on Analytical Chemistry and Applied Spectroscopy (Pittcon), March 2009, Chicago, IL.

- Cornett, C., Wermeling, J., Halligan, A., Selle, A., Vircks, K., Jacobs, J., Vyhnamek, A., McCrary, C. “Building a Better Mouse Trap for Ignitable Liquids: Fast GC Meets Hydrogen Carrier Gas.” Oral presentation at the 37th Annual Midwestern Association of Forensic Scientist Meeting, October 2008, Des Moines, IA.

- Halligan, A., Wermeling, J., Jacobs, J., Selle, A., Vircks, K., Vyhnamek, A., McCrary, C., Cornett, C. “Putting Fast GC to the Test in Ignitable Liquid Analysis: An Evaluation of Standards and Matrices” Poster presentation at the 37th Annual Midwestern Association of Forensic Scientist Meeting, October 2008, Des Moines, IA.

IMPLEMENTATION

Switching to Fast GC from a conventional unit is relatively simple. It involves upgrading the power source to either a 220 V or 240 V (preferred) service, and installing a high-heat oven shroud, power cord, and narrower capillary column. The instrumentation upgrade may cost as little as $1,000 - $2,000.

CONTACTS

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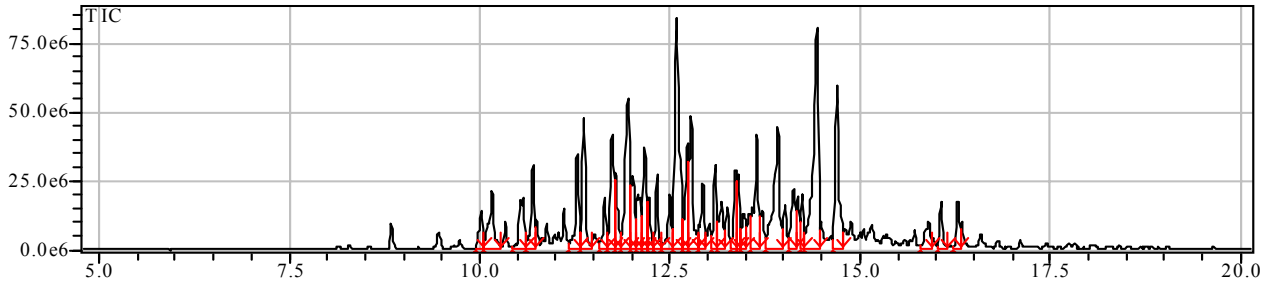
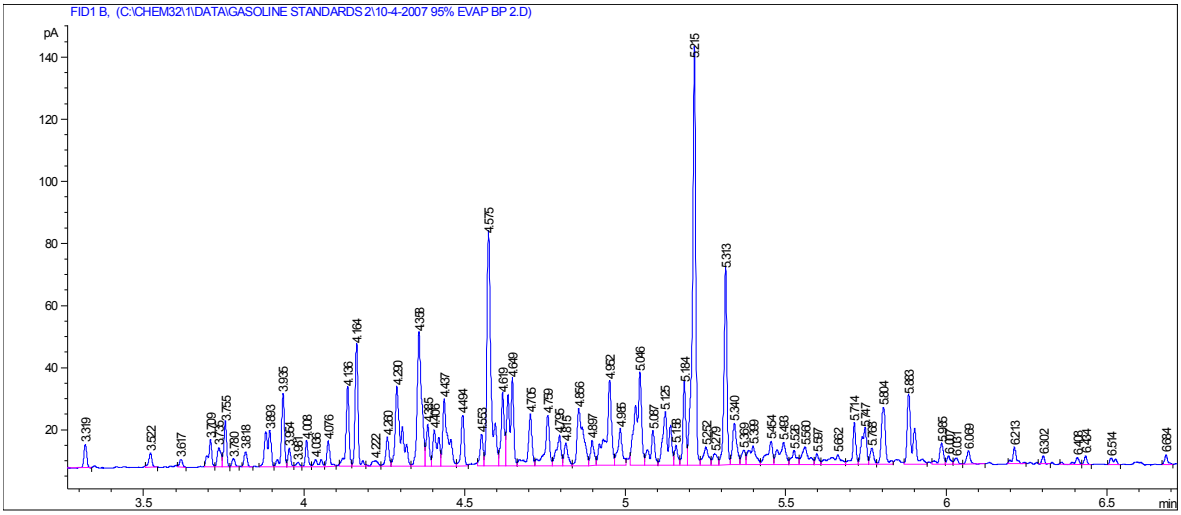


(Conventional GC)



(Fast GC)

Figure 1. A Comparison of Fast GC (Hydrogen Carrier Gas) and Conventional GC (Helium Carrier Gas) Separations of 95% Evaporated Gasoline

Micromechanical Cantilever Based Sensors for Chemical Species Detection

FORENSIC TECHNOLOGY NEED

Current sensor systems require extensive sample preparation or specialized instrumentation to identify molecules of controlled substances such as cocaine. High specificity and sensitivity Micromechanical Cantilever (MC)-based sensors provide an invaluable tool for forensic science because of their portability, capability for detection, and capability for identification with high sensitivity and specificity. Successful completion of the project will buttress research efforts towards developing portable sensors for chemical species detection by integration of receptor layer coated micro-cantilevers and high resolution interferometry into a single microfabricated chip.

TECHNOLOGY DESCRIPTION

Specific aims of this project are to:

- develop robust miniature sensors for high-resolution measurement of surface stress associated with the formation of affinity complexes on the sensitized surface of micro-cantilevers

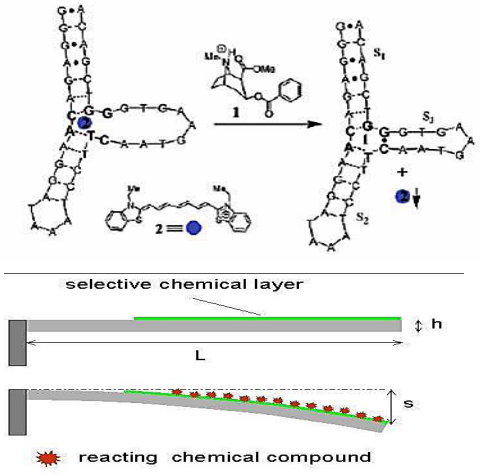


Figure 1. Aptamer based MC sensor.

- characterize the sensitivity and specificity of cocaine detection with MC-based sensors functionalized with suitable receptor layers of aptamer molecules.

- functionalize micro-cantilevers with an aptamer capable of sensitive and specific detection of cocaine molecules

METHODOLOGY

In this project, a proof-of-concept is developed for the sensing approach by building an MC-based sensor functionalized with aptamer molecules for sensitive and specific detection of cocaine molecules.

ACCOMPLISHMENTS AND ONGOING WORK

A detailed design and fabrication plan was developed to assemble the MC-based sensor for high resolution measurement of surface stress. Detailed design consisted of two micro-mechanical cantilevers (a sensing/ reference pair), two microlens arrays (MLA1 + MLA2), fiber optic cables, micro-actuators and alignment accessories.

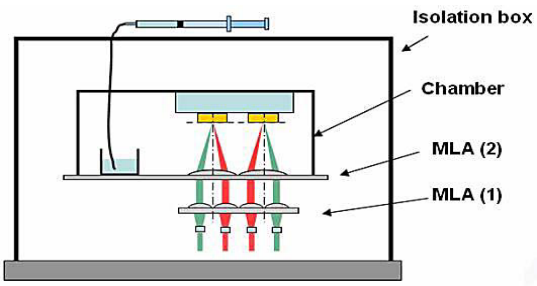


Figure 2. Alkanethiol SAM formation.

Model systems were developed and experiments on Alkanethiol SAM Formation and DNA Hybridization were conducted. They

demonstrated sensor performance in ambient and aqueous environments, and validated the functional capability of a DNA aptamer in the micro-cantilever.

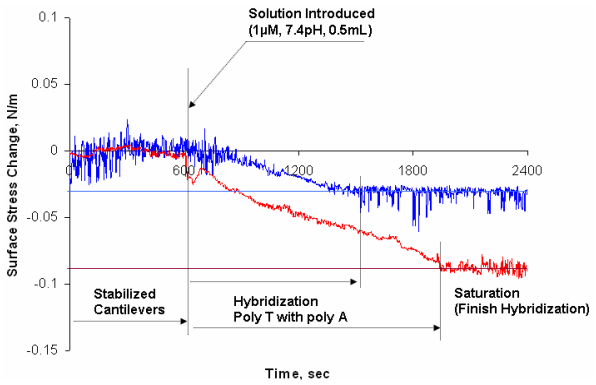


Figure 3. DNA hybridization.

The ability of the aptamer to bind with cocaine by colorimetric displacement assay and fluorescence assay using Fluorescence Resonance Energy Transfer (FRET) was also established. For these assays, the synthetic oligonucleotide anti-cocaine aptamer (5' - GGGAGACAAGGAAAATCCT TCAATGAAGTGGGTCGACA-3') was used.

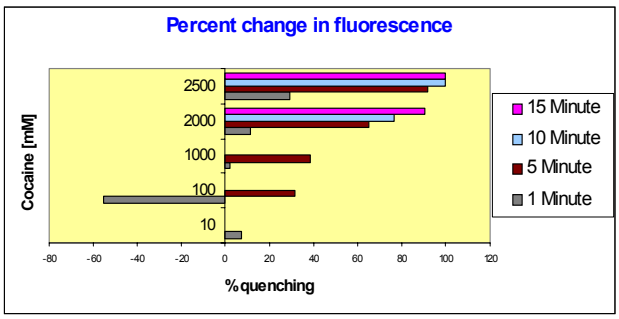


Figure 4. FRET Quenching results.

TECHNOLOGY BENEFITS

Development of MC-based sensors symbolize important breakthroughs for forensic science because of the tremendous sensitivity that can be achieved by aptamer-coated micro-cantilevers and the specificity imparted by aptamers for identification of chemical species at concentrations of parts-per-billion. Such sensitivity revolutionizes forensic analysis of controlled substances, explosives, toxic species, biological molecules, and DNA matching required for crime-scene identification.

COLLABORATION

This project is a collaborative effort between Iowa State University and the Michigan State Police. The PIs designed and developed the MC-based sensor, while the Michigan State Police contributed its expertise in controlled substance identification for sensor development.

DISSEMINATION

Sensor design and initial research findings were presented at an SPIE symposium and at the MFRC annual meeting. Upon completion of the project, research results will be published in a peer-reviewed forensic science publication. A final technical report will also be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Shrotriya, P., Kang, K., Marquardt, J. "Surface stress sensors for detection of chemical and biological species." SPIE 14th International Symposium on Smart Structures and Materials Nondestructive Evaluation and Health Monitoring, March 2007, San Diego, CA.

- Shrotriya, P., Nilsen-Hamilton, M., Sachau, S., Kang, K. "Micromechanical Cantilever (MC)-Based Sensors for Chemical Species Detection". Midwest Forensics Resource Center Annual Meeting, April 2008, Bemidji, MN.

IMPLEMENTATION

This project established proof-of-concept for chemical species detection by MC-based sensors. The PIs utilized the results of this research to seek additional funding from NIJ to develop a portable Micro Electron Mechanical Systems (MEMS) sensors. An award for funding was recently made.

CONTACTS

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Optimization of Headspace-Solid Phase Microextraction for Organic Impurity Profiling of Ilicit MDMA Tablets

FORENSIC TECHNOLOGY NEED

Current profiling of illicit methylene dioxy methamphetamine (MDMA) tablets is based on physical and chemical characterization of tablets. As tablets with the same physical characteristics do not necessarily have the same chemical composition, chemical profiling has become the preferred method used by law enforcement agencies.

Conventionally, organic impurities are extracted using liquid-liquid extraction (LLE) procedures and then analyzed by gas chromatography-mass spectrometry (GC-MS) to generate an impurity profile. Although the success of this technique has been documented in the literature, the procedure has a number of disadvantages, including: relatively large sample masses are required; trace impurities may be masked by the controlled substance when present at high concentrations; and use of organic solvents may require expensive disposal.

TECHNOLOGY DESCRIPTION

In this research, an alternative extraction procedure is developed and optimized based on headspace-solid phase microextraction (HS-SPME). In HS-SPME, a polymeric fiber is exposed to the headspace of a liquid or solid sample. Impurities absorb and/or adsorb to the fiber and are pre-concentrated on the fiber during the extraction procedure. The fiber is then removed from the sample vial and inserted into the heated inlet of the GC, where impurities are desorbed directly from the fiber and

Figure 1. Analyst inserting SPME fiber into GC inlet to desorb impurities.

HS-SPME reduces or eliminates the use of organic solvents and associated disposal costs. With the correct choice of fiber coating, impurities can be preferentially extracted over the illicit substance.

METHODOLOGY

In this study, HS-SPME procedures for the extraction of organic impurities from illicit MDMA tablets are developed. Two different fiber types are investigated, a statistical experimental design procedure is used to optimize the extraction time and temperature for each. The optimal fiber type is assessed based on the number of impurities extracted, as well as repeatability and reproducibility of the extraction. The optimized HS-SPME is then compared to a conventional LLE procedure, in terms of the number and level of impurities extracted, repeatability, and

reproducibility of the two extraction procedures.

ACCOMPLISHMENTS AND ONGOING WORK

A HS-SPME procedure for the extraction of organic impurities from tablets containing MDMA was developed and optimized. The SPME fiber was exposed to the headspace of a buffer solution containing the solid MDMA sample.

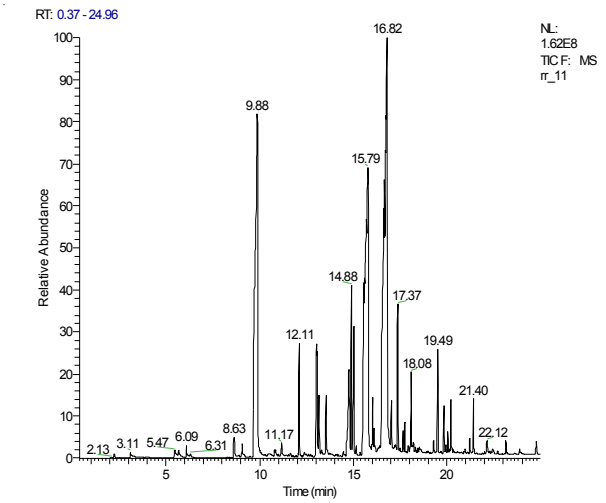

Figure 2. HS-SPME extraction from carbonate buffer solution of impurities from a homogenized batch of MDMA tablets.

Relative standard deviations were typically less than 15% for the early eluting impurities (retention time less than 14 minutes), using an extraction time of 30 minutes at an extraction temperature of 60°C.

The optimized HS-SPME procedure was compared to a conventional LLE procedure in terms of the number of impurities extracted as well as the repeatability and reproducibility of the extraction. In general, only 12 impurities were extracted using the LLE procedure, compared to 16-22 impurities using the HS-SPME procedures, depending on extraction time and extraction temperature.

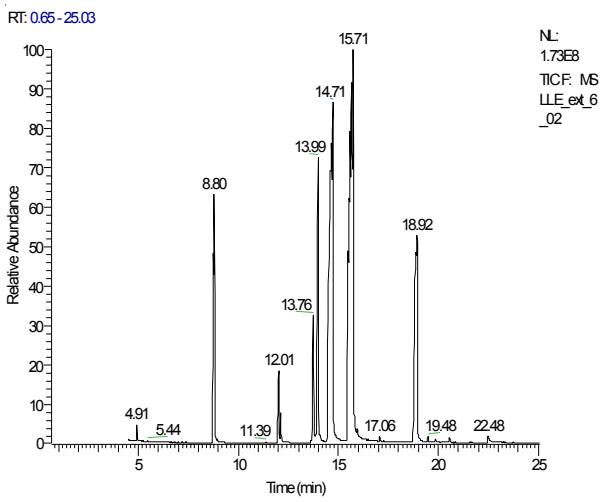

Figure 3. Liquid-liquid extraction of impurities from a homogenized batch of MDMA tablets.

Impurity profiles of MDMA tablets from five different exhibits were obtained using the HS-SPME procedure, with analysis by GC-MS. All five exhibits were differentiated based on the impurity profiles obtained using the optimized HS-SPME procedure for impurity extraction. This development is significant as it demonstrated the potential of HS-SPME in organic profiling; a concept not previously realized.

While the MFRC funded part of the research has been completed, the research is ongoing in the laboratory using departmental and other funding mechanisms.

TECHNOLOGY BENEFITS

HS-SPME offers several advantages over conventional LLE procedures. They include: improved organic impurity extraction, and informative impurity profiles coupled with objective comparisons. As such, they allow impurity profiling to become a more useful tool for forensic practitioners.

COLLABORATION

This project is a collaboration between Michigan State University and the Michigan State Police Crime Laboratory. The collaborator provided the MDMA tablets.

DISSEMINATION

Results of the work were disseminated at the Midwestern Association of Forensic Scientists Fall Meeting 2007. A poster presentation was also made at the American Academy of Forensic Sciences, February 2008, in Washington, D.C. Currently, a manuscript is being prepared for submission to the Journal of Forensic Sciences. Results of the work will also be disseminated in a final technical report on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Meisinger, S. and Waddell, R. "Optimization of Headspace – Solid Phase Microextraction (HS-SPME) for Organic Impurity Profiling of Seized MDMA Tablets." Midwestern Association of Forensic Scientists Fall Meeting, September 2007, Traverse City, MI.

- Meisinger, S. and Waddell, R. "Comparison of Extraction Procedures for Organic Impurity Profiling of Seized MDMA Tablets." American Academy of Forensic Sciences 60th Annual Meeting, February 2008, Washington, D. C.

IMPLEMENTATION

The Drug Enforcement Administration has shown an interest in the research and asked to be kept informed of progress. Currently, the methodology is still under development and opportunities for implementation are not yet available.

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The Temporal Fate of Drugs in Decomposing Tissues*

FORENSIC TECHNOLOGY NEED

Interpreting drug concentrations in decomposed remains is difficult. Postmortem tissues that are routinely collected and analyzed to provide the largest comparative database for interpretation (blood, urine, vitreous humor) are frequently lost in the early stages of putrefaction.

When drugs are found in weathered tissues, there is currently little or no information available to help guide the toxicologist (and subsequently the pathologist) in evaluating whether a drug or drugs played any significant role in causing the death.

TECHNOLOGY DESCRIPTION

This study monitors the concentration of drugs, in multiple tissues and organs, during whole body decomposition.

Specific questions addressed are:

- How does the concentration of drugs change during tissue decomposition?
- How long do drugs and metabolites persist in tissues at detectable levels?
- Which collection sites are most useful for detecting drug exposure and interpreting results?

The study uses *Sus domestica,* the domestic pig. Pigs are selected because their size is comparable to humans allowing high-level dosing and sequential sampling of multiple tissues. Also, their physiology is similar to humans. Specifically, their digestive and cardiovascular physiology allow for drug absorption and distribution that closely mimics those of humans.

Figure 1. Animal research enclosure site.

METHODOLOGY

The concentration of 16 drugs in tissue from decomposing pigs weighing 120-150 lbs., is monitored in blood, brain, liver, kidney, muscle, maggots, and soil during one week.

Pigs are divided into groups (n=5) with each group receiving four drugs. Drug cocktails prepared from pills (capsules or tablets) are obtained as pharmaceutical formulations.

Drugs tested include: morphine, amitriptyline, citalopram, diazepam, methadone, fluoxetine, doxepin, acetaminophen, oxycodone, diphenhydramine, venlafaxine, carisoprodal, verapamil, zolpidem, and propoxyphene.

Sacrifice of pigs (using intracardiac pentobarbital) is four hours after dosing (gavage), with tissue collection at 4, 24, 48, 96, and 168 hours post-dosing. Samples are frozen until assay.

** Approval to perform animal research was obtained from the Ohio State University Institutional Laboratory Animal Care and Use Committee.*

Detection and quantitation of drugs is achieved through Solid Phase Extraction (SPE) followed by Gas Chromatography-Mass Spectrometry (GC-MS) analysis. Morphine is derivatized with heptafluorbutyric anhydride and assayed by Selective Ion Monitoring (SIM).

ACCOMPLISHMENTS AND ONGOING WORK

Twenty-four pigs were obtained for testing. Nine of which were sacrificed in the initial attempt: five for testing and four as controls. Control pigs were included to determine whether total organ weight changed as a result of necrospy.

The initial attempt to dose the pigs through their food was unsatisfactory. The amount of drugs consumed was of very low levels and varied from animal to animal. It was decided that drugs needed to be administered by gavage as slurry.

Figure 2. Dosing of pigs allowed to live four hours after gavage.

It was also found that the rate of decomposition was much faster than anticipated. Brain and kidneys were not available after forty-eight hours, while muscle and liver persisted for one week.

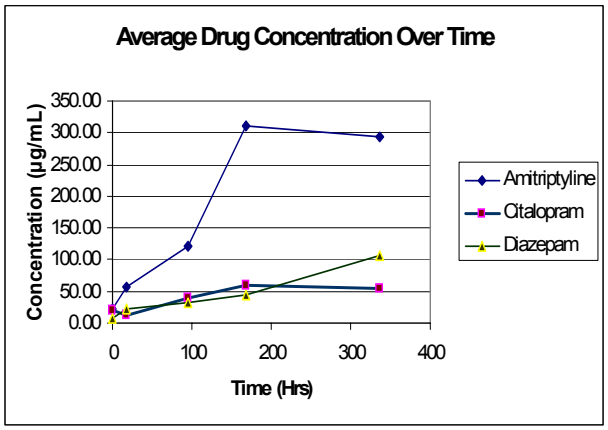

Figure 3. Results of the four drugs in liver tissue collected for two weeks.

Concentrations of drugs analyzed typically increased with time during decomposition. This was most pronounced (and statistically significant) for amitriptyline. It was concluded that attempting to interpret drug levels in decomposed bodies may lead to incorrect conclusions about cause and manner of death.

TECHNOLOGY BENEFITS

This investigation provides important insights into the fate of drugs in various tissues over an extended period of decay. The information gained allows pathologists, toxicologists, and criminologists to interpret case results more accurately thereby providing a more complete conclusion regarding cause of death and fate of victims.

COLLABORATION

This is a collaborative project between the Franklin County Coroner's Office (FCCO) and the Ohio State University (OSU). Pathologists from both institutions assisted in the collection of tissues. Toxicology was performed at the FCCO, while a biostatistician performed statistical analysis of results at OSU. Approval to perform animal research (the site of decomposition was leased from OSU) was obtained at OSU.

DISSEMINATION

Presentations of research findings will be made at the Society of Forensic Toxicology, October 2008, Phoenix, AZ . A manuscript is currently being prepared for submittal to the Journal of Forensic Sciences. The project and its research findings will also be disseminated in a final technical report posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Wyman, J., Dean, D., Yinger, R., Simmons, A., Brobst, D., Bissel, M., Silveira, F., Shott, R., Ohr, J., Tatarek, N., and Lewis, B. “The Temporal Fate of Drugs in Decomposing Porcine Tissue.” Paper submitted to the Society of Forensic Toxicologists (SOFT), October, 2008, Phoenix, AZ.

IMPLEMENTATION

As a result of this work, the Franklin County Coroner’s Office in Columbus, OH, no longer tries to interpret therapeutic, toxic, and lethal drug concentrations in decomposing bodies.

Some of the findings from this study were incorporated in presentations on “The Toxicology of Suicide” given at the Society for the Scientific Detection of Crime (Columbus, OH; March 17, 2008) and at the International Association of Coroners and Medical Examiners Annual Conference (Cincinnati, OH: June 12, 2008).

A medical examiner from the city and county of San Francisco, CA, also expressed an interest in the research results for possible application.

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Ultra-Fast Gradient Elution HPLC as a High Throughput, High Information Content Screening Tool for Drugs of Abuse

FORENSIC TECHNOLOGY NEED

Gradient elution high performance liquid chromatography (HPLC) with diode array detection is a common method used for screening and even identifying drugs of abuse in biological samples.

Although the technique has tremendous chemical selectivity and can produce precise retention time data under well-controlled conditions, the technology is quite slow, requiring 20-30 minutes per run.

As the sample load in forensic laboratories continues to increase, using HPLC techniques to deliver analytical sample judgement in a timely fashion is becoming more difficult.

TECHNOLOGY DESCRIPTION

In a previously funded project, the principal investigators developed an ultra-fast gradient elution reversed-phase HPLC with diode array detection as a fast tool for screening samples for regulated intoxicants. Through a combination of precise retention measurements and chemometric analysis of the spectro-chromatograms, both the speed and selectively of older HPLC methods could be significantly improved. This project focuses on enhancing these improvements for drugs of abuse.

METHODOLOGY

To improve the selectivity of the previously developed rapid liquid chromatography intoxicant screening method, a secondary "orthogonal" column with different selectivity than the standard (primary) column is used. Analytes that cannot be identified in the first separation (due to incomplete chromatographic or spectroscopic resolution) are now subjected to a second, orthogonal ultra-fast liquid chromatography separation resulting in a dramatic reduction in the number of indistinguishable analytes at very low cost in time.

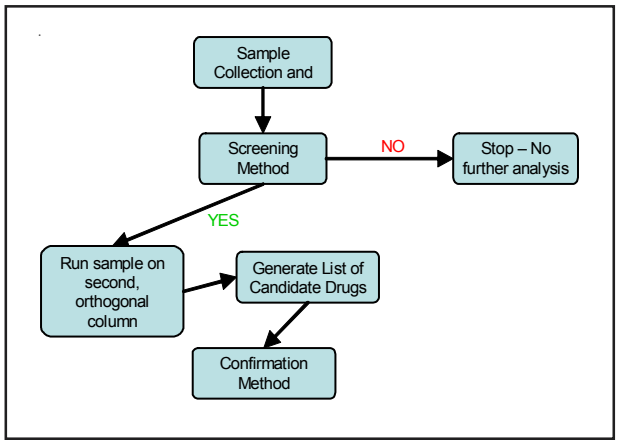

Figure 1. Two Column Approach

To improve the speed of the liquid chromatography method, recently commercialized very small stationary phases that use the "core-shell" concept are applied. By testing a commercial reversed (C18-type) phase and a novel hydrophobically-assisted cation exchange phase, it may be possible to do reproducible gradient elution chromatography in as little as 1 minute, while retaining resolution on longer time scales.

To optimize chromatographic resolution, a newly developed general purpose optimization scheme is applied. This may result in an increase in peak capacity of gradient elution liquid chromatography. By using real samples whose compositions have been pre-assessed by accepted methods, the sensitivity and specificity of the methodology can be evaluated.

ACCOMPLISHMENTS AND ONGOING WORK

Based on Fs values, twelve columns were selected to test the Snyder-Dolan reversed phase selectivity classification scheme for predicting similarities and differences in the stationary phase behavior of representative drugs.

Set Type	Column A	Column B	Column C	Column D	Fs (vs. SB C18)
I (Similar)	Zorbax SB C18 -Agilent	ACE 5 C18 -Mac Mod	Discovery C18 -Supelco	Alltima HP C18 -Alltech	8.1~13.6
II (Similar)	Beta Basic Phenyl -Thermo	Protosil 60-5 Phenyl -Bischoff	Zorbax Phenyl -Agilent		18.1~29.4
III (Similar)	Hypersil Prism C18 -Thermo	Bonus RP -Agilent			255.1, 266.7
IV (Different)	ZirChrom PS -ZirChrom	Nova Pak CN HP-60 -Waters	Inertsil CN -GL Science		48.8-230.5

Table 1. The twelve columns for this study.

The first three groups were each comprised of reversed phases that were nearly identical in terms of phase parameters while the phases in the fourth groups were extremely different.

All columns were checked with 16 standard solutes and then tested with twenty-five highly varigated drug substances, inlcuding benzodiazepines, antihistamines, and antidepressants under both isocratic and gradient conditions. The retention times of all drugs on each column were measured and used to compare column selectivity.

Results were consistent with those obtained with the 16 standard solutes, thereby verifying the value of the Snyder-Dolan model of reversed-phase selectivity triangle for predicting the similarity and differences of phase behavior for a wide variety of drugs.

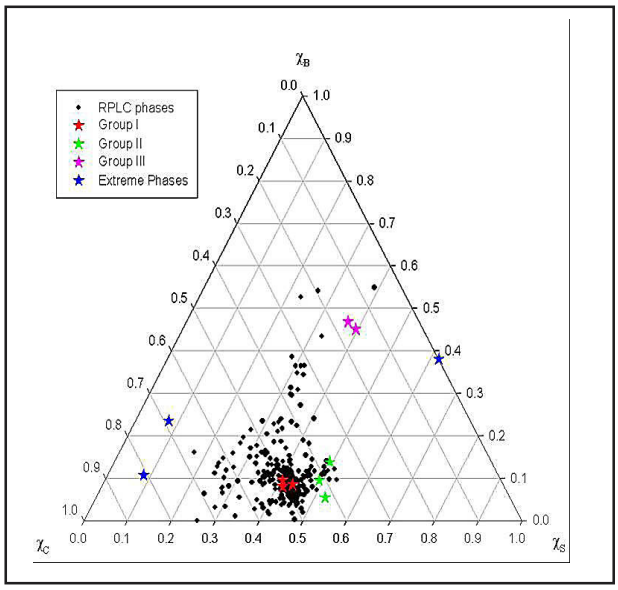

Figure 3. Stationary phase selectivity (S-B-C) triangle plot.

It was found that the Snyder-Dolan database of 350 columns can be used to reliably choose similar and very different columns for drugs while the selectivity triangle model based on Snyder's parameters can be used for selecting maximally orthogonal columns for drugs. A few promising candidate columns for use in a two-column screening approach were identified, and the PI is currently working on "wedding" the orthogonality of the conventional C18-type phase and the SO_3-HC-C8 phase with the high speed of the recently introduced micro-particulate core-shell particles. The distributor of these materials is supplying underivatized material to facilitate transfer of the SO_3-HC-C8 phase to the new type of particle.

The PI is also studying the sensitivity and specificity of the methodology by evaluating real samples whose composition have been

pre-assessed by LC-MS.

TECHNOLOGY BENEFITS

This work will vastly improve the screening for drugs in blood, urine, and other tissue samples. It will also make a dramatic impact in forensic toxicology.

COLLABORATION

This project is a collaborative effort between the University of Minnesota, and the Minnesota Bureau of Criminal Apprehension Forensic Science Laboratory. The collaboration has consisted of forensic scientists from the BCA Forensic Science Laboratory visiting the PI's laboratory and attending group meetings. In return, the PI and his group visited the BCA to work on specific project aspects.

DISSEMINATION

Information on and data from the project were presented at professional meetings and conferences, including the American Academy of Forensic Science, the HPLC Symposium, and the Midwest Forensics Resource Center Annual Meeting.

Additionally, research information and findings will be published in such journals as Analytical Chemsitry, the Journal of Chromatography, the Journal of Analytical Toxicology, and the Journal of Forensic Sciences. A final technical report on the project and its findings will also be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Stoll, D., Wenzhe Fan, Paek, C., Yu Zhang, Carr, P. "Development of a Rapid HPLC-Based Screening Approach for Intoxicants-Selection of Orthogonal Columns to Maximize Identification Power." Midwest Forensics Resource Center Annual Meeting, April 2008, Bemidji, MN.

- Wenzhe Fan, Carr, P., Schellinger, A., Pritts, W. "Application of Snyder-Dolan Classification Scheme to the Selection of Orthogonal Columns for Pharmaceutical Analysis." 32nd International Symposium on High Performance Liquid Phase Separations and Related Techniques, May 2008, Baltimore, MD.

- Wenzhe Fan, Schellinger, A, Carr, P. "Development of a Snyder-Dolan Based Approach to Picking Orthogonal Phases for Fast Screening of Illicit Drugs and Impurity Profiling of Pharmaceuticals. Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy (Pittcon), March 2009, Chicago, IL.

IMPLEMENTATION

After demonstrating adequate predictive capabilities, the methodology will be transferred to the BCA where the technique will be used to establish performance statistics.

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A Steganalyzer Package for Forensic Applications

FORENSIC TECHNOLOGY NEED

The use of steganographic software for hiding information in image files is becoming more widespread for illicit purposes. While steganalysis algorithms are abound in the academic literature, there are few software programs that address the needs of local police departments who perform computer forensic functions for steganalysis.

Currently available steganalyzer packages are very expensive and require extensive training of forensic personnel. This research project attempts to make a very limited but practical steganalysis software program available to a local crime laboratory for testing and evaluation.

TECHNOLOGY DESCRIPTION

In a previously funded project, proof-of-concept on the use of an artificial neural network for wavelet steganalysis (ANNTS) was demonstrated. The software developed simply scanned images for hidden content. It exhibited good steganalysis detection rates and ease of use by non-specialists.

Specific aims of this project are to make the software available for practical use in computer forensics. This is achieved by:

- enabling more images to be scanned and inspected
- adding two more targeted detection techniques for images embedded with S-Tools and JP Hide & Seek
- extending the capabilities of ANNTS by developing a detection technique for image data

METHODOLOGY

The current capacity of ANNTS is to scan a single image at a time. In this project, the code will be modified so that a file folder of image data can be inspected, and the results be written to a file. In addition, the software user interface will be slightly modified to make the meaning of labels written on screen clearer.

The current version of ANNTS can identify images embedded with the freely available jsteg-jpeg and F5. In this project, two more detection techniques will be added: These are two widely used embedding techniques available from the nearly 100 freeware at segoarchive.com.

The current capabilities of ANNTS will be extended by developing a blind (or general) detection technique that is based on the dual-tree complex wavelet transform (DT-CWT) and a partially ordered Markov model (POMM) for image data. The DT-CWT transform is a recently developed transform, developed as a more general vision of the traditional wavelet transform. To date, neither the transform nor the POMM has been used for steganalysis. Yet, they show great promise as blind detection techniques.

ACCOMPLISHMENTS AND ONGOING WORK

This is a new project that has not started yet.

TECHNOLOGY BENEFITS

The research will provide crime laboratories with a software package that

addresses basic stenography needs for forensic applications. Currently, few crime laboratories have these capabilities.

COLLABORATION

This project is a collaborative effort between Iowa State University and the Iowa Division of Criminal Investigation (DCI). The software program will be developed at Iowa State University and tested and evaluated by DCI.

DISSEMINATION

Project findings will be disseminated through presentations at regional and national conferences, including the Association of Digital Forensics Security and Law, the Digital Information Hiding Workshop, and (if possible) the Internet Crimes Against Children (ICAC) conference. A manuscript on the research and its findings will also be prepared for submission to the Journal of Digital Forensic Practice, while a technical report on the project will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

This is a new project with no publications or presentations to date.

IMPLEMENTATION

Once the software package is developed, it will be beta-tested and evaluated. DCI personnel will receive instruction for use as well as a user's manual. Feedback will be used to make adjustments to the program.

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Application of a Crystal Orientation Method to Forensic Physical Matching of Metal Surfaces along a Fracture Line

FORENSIC TECHNOLOGY NEED

Examples of metal fragments found at a crime scene include knife tips, pieces from weapons, pry tools, or automobile parts such as antennas or trim pieces. A physical match between two surfaces is routinely viewed as definitive proof that the fracture surfaces were generated from the same part. However, in the Summer 2005 issue of the Association of Firearm and Toolmark Examiners (AFTE) Journal, Katterwe stated that there were current “trial challenges” to the practice of fracture matching examinations by toolmark examiners. To date, there has been little systematic effort to establish a basis for the uniqueness of a physical match of surfaces.

TECHNOLOGY DESCRIPTION

Conventional matching of the fracture surfaces utilizes physical characteristics of the fracture such as shape, color and other features. While useful, these features unfortunately do not lend themselves to an objective or quantitative evaluation of the uniqueness of a fracture. The objective of this study is to provide an additional method for establishing characteristics of a fracture based on atomic arrangements.

Metals are composed of crystals whose atoms are arranged in regular long periodicity. The atomic arrangement of these atoms is precisely known and can be determined with a high degree of accuracy. By probing the arrangement of atoms and combinations of metal crystals within and along a metal, a determination can be made that two separate pieces of metal are indeed from a single piece.

METHODOLOGY

The study tests if the surface crystal orientations of the fractured crystals across the fracture plane for two surfaces are in fact unique and constitute a reliable, quantitative measure to determine if the two pieces sharing the fracture plane at one time belonged to the same piece. This is achieved by examining the uniqueness of crystal orientations within the requirements necessary for accurate determination of crystallography using Electron Back Scatter Defraction (EBSD).

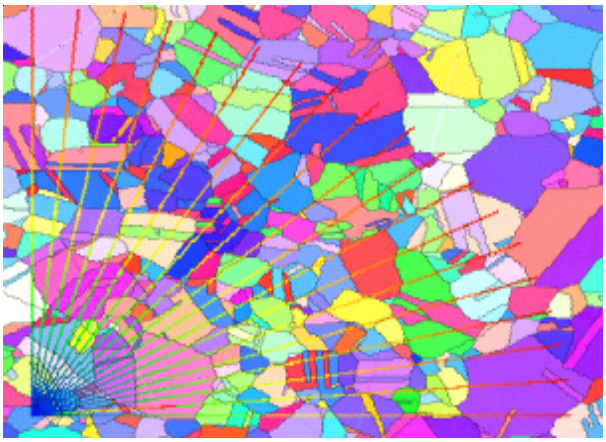

Figure 1. Grid placement for point-to-origin misorientation vector with 5° angular separation between vectors.

EBSD is a point-to-point (grain-to-grain) measurement on the surface of the metal that can be used to determine the orientation of individual crystals. EBSD’s basic operation collects electron back-scattered patterns using a specialized collector on the scanning electron microscope. Orientation patterns are generated by sample interaction with the electron beam.

ACCOMPLISHMENTS AND ONGOING WORK

Metal fractures of two Fe-based alloys were examined: a 304 standard stainless steel and an iron-gallium alloy. The study showed that, in the case of intragranular fracture, pieces of grain can be associated across the fracture surface, and that it is feasible to associate two fracture pieces with sequence of grain orientations.

It also showed that it is possible to use the sequence of the difference in orientation between grains (misorientation) along a length on one side of the fracture surface to associate the other side of fracture surface.

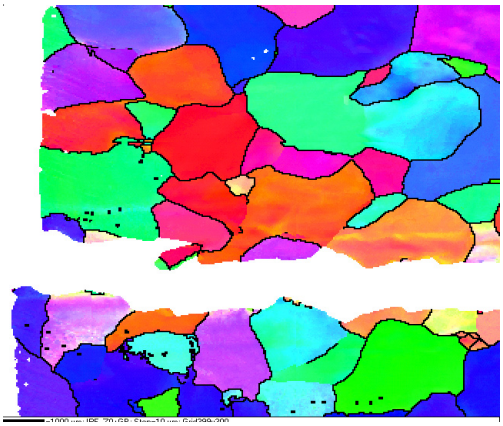

Figure 2. Orientation imaging microscopy maps of the top and bottom of the steel sample including the fracture edge.

Orientation angles for grains and misorientation values between grains were calculated and the resulting values were compared for grains across fracture surfaces. For iron gallium samples, it was shown that it is feasible to use surface crystal orientation to associate one fracture edge to another.

Regarding the uniqueness of crystal orientations, it was estimated that for a sequence of six randomly oriented grains along a fracture, the resulting probability that the same sequence would occur again is 2^{-31}.

Edge	Color	Angle Φ1	Angle Φ	Angle Φ2
Bottom	Pink	341°	29°	56°
	Purple	162°	16°	47°
	Brown	202°	19°	3°
Top	Pink	343°	28°	53°
	Purple	169°	11°	38°
	Brown	198°	19°	6°

Table 1. Three orientation Euler angles for grain parts of two sides of fracture.

Finally, it was found that besides crystallographic orientation, another parameter which has potential for being used in combination with orientation is grain size and shape along the fracture line. This is a facet which could be examined in future work.

TECHNOLOGY BENEFITS

The outcome of this study is a workable measure of the orientation of crystals along the fracture line of many materials, including metal fractures of knives, pry tools, and car antennas. The data collected strengthens the scientific foundation of the fracture match practice with data to begin the task of estimating error rates.

COLLABORATION

This work was conducted at the Ames Laboratory in collaboration with Jim Kreiser, a retired toolmark examiner from the Illinois State Police. Kreiser performed the preliminary match of the test materials prior to the EBSD measurements. The principal investigators generated the EBSD experimental data.

DISSEMINATION

Results of the feasibility study were presented at the Midwest Forensics Resource Center Annual Meeting, April 2007, in Madison, WI. A poster of the results was presented, and discussions with forensic professionals were conducted, at the IAI meeting, July 2007, in San Diego, CA. Research results will also be presented as a paper submitted to a forensic journal. Finally, the project and its findings will be disseminated in a technical report posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Lograsso, B., Lograsso, T., Glamm, R. "Crystallographic Descriptors of a Metal Surface along a Fracture Line." Poster presentation at the International Association of Identification, International Educational Conference, July 2007, San Diego, CA.

- Lograsso, B., Lograsso, T., Glamm, R. "Application of Crystal Orientation Method to Fracture Evaluation." Oral presentation at the Midwest Forensics Resource Center Annual Meeting, April 2007, Madison, WI.

- Lograsso, B., Lograsso, T. "Application of a Crystal Orientation Method for Matching Surfaces Along a Fracture Line." Accepted for the Proceedings of IMECE08, October/November 2008, Boston, MA.

- Bingham, M., Nordman, D., Vardman, S. "A Tractable Class of Distributions for Rotations in 3 Dimensions and Some Applications to Measured Crystal Orientations." Submitted to the Journal of American Statistical Association.

IMPLEMENTATION

The purpose of this study was to evaluate the feasibility of using surface crystal orientation to associate or differentiate metal fracture fragments. Additional research is needed to determine error rates associated with performing physical matches.

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High-Speed Digital Video Analysis of Bloodstain Pattern Formation from Common Bloodletting Mechanisms

FORENSIC TECHNOLOGY NEED

Bloodstains form on two dimensional surfaces. As a result, bloodstain pattern analysis is a study of the aftermath of a blood transfer event. From the size, shape, and distribution of bloodstains, inferences can be drawn regarding the mechanism that gave rise to their formation.

To date, most investigators rely on pattern observation and laboratory simulation to recognize and classify bloodstain patterns. Relatively little has been documented about the dynamics of the blood transfer event. Yet, understanding the dynamics of blood transfer is critical to the sound interpretation of the resultant bloodstain pattern.

TECHNOLOGY DESCRIPTION

The objective of this study is to analyze and document the dynamics of common blood transfer and to compile a set of video clips of common blood transfer events that can be used by instructors in a bloodstain pattern course.

Specific aims of the study are to analyze:

- the dynamics of the collision between a blood drop and a hard surface
- the dynamics of the collision between a blood drop and the surface of a fabric as well as the cast-off from a moving bloodied object
- the impact splatter from beating, kicking, and stomping
- the impact splatter from shooting

METHODOLOGY

The study aims to document the three-dimensional dynamics of blood transfer events. To achieve this, a series of experiments are designed to maximize available light, provide high contrast images, and where possible calibrate the scale of the experiment.

For each experiment, digital video sequences are captured, stored and backed up on portable hard drives. Bloodstain patterns created in each experiment are collected and preserved.

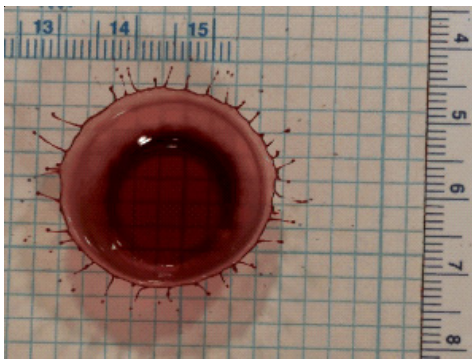

Figure 1. A blood drop falling onto a hard surface.

A wide range of target surfaces, such as cardboard, building materials, carpet and various types of clothing, is used for the disposition of blood and bloodsplatter.

Experiments are set up using standard laboratory equipment and some specially built devices for producing and capturing blood splattered by different mechanisms.

Human blood is drawn from laboratory donors and is used within 72 hours for all experiments. Blood is stored and refrigerated

when not in use and is heated to room temperature during use.

High Speed Digital Video (HSDV) is used to analyze and document the dynamics of common blood transfer events. HSDV cameras are ideally suited to see, measure, and understand high speed process offering outstanding image quality at frame rates up to several thousand per second.

ACCOMPLISHMENTS AND ONGOING WORK

Over 500 video sequences were collected. Most of the blood events studies were highly complex and variable. The collection of video sequences only represents a set of examples of the events in question. Yet, the sequences provided valuable data on the mechanism of blood events.

The following events were documented:

- passive drops formation from five different objects
- passive drops of three different volumes free falling from 1-9 meters.

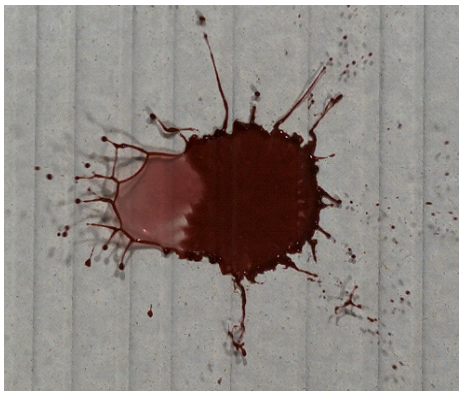

Figure 2. Blood drop landing on a cement tile

- passive drops from different heights impacting different surfaces
- passive drops impacting three different surfaces at known angles from 10° to 90°
- impact splatter resulting from blood dripping into blood
- impact splatter resulting from the impact of five instruments on bloodied surfaces

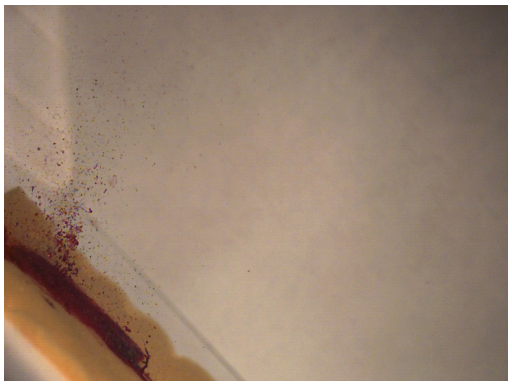

Figure 3. Blood droplets blown back by gases from firearm

- impact splatter resulting from the stomping, slapping, and flicking of blood
- formation of impact splatter stains on cotton fabric at various angles
- gunshot induced bloodsplatter produced by three different caliber handguns at up to four distances from the blood source
- swing cast-off from five different objects
- cessation cast-off
- large volumes of blood dripping from four heights
- large volumes of blood projected from four heights and at two angles
- projected blood from coughing and exhaling through the nose and mouth

- contact blood staining produced by fingers, various fabrics, and hair

AVI files, using the Cinepak codec compression were prepared from a representative set of the video clips. The files can be played by media players such as Windows Media Player. Alternatively, the Photron Fastcam Viewer (PFV) can be used if frame-by-frame control is required. The PFV can be downloaded free from the internet.

TECHNOLOGY BENEFITS

In the past, bloodstain pattern analysts were trained in bloodstain pattern analysis (BPA) primarily by studying the aftermath of bloodletting events. The recording of major bloodletting events by high speed digital video, and making these videos available to the forensic community, enhances the ability of the bloodstain pattern analyst to understand the dynamics of blood transfer that gave rise to bloodstain pattern.

The study of how blood is deposited in specific events will assist in the differentiation of closely related events. As such, it will contribute to the underlying science behind BPA methods and the validation of current bloodstain pattern recognition methods. Finally, the foundations of BPA opinion evidence in court will be strengthened by this study. The technology will enhance the expert witness' opinion and help to satisfy the continued demand by courts to use the most advanced technologies available.

COLLABORATION

This project is a collaborative effort between staff from the Minnesota Bureau of Criminal Apprehension, the Institute of Environmental Science and Research in New Zealand, and a forensic consultant. The advantage of this collaboration is a broader international perspective of the research need and a connection with a research program that has an established network of partnerships.

DISSEMINATION

Research results will be presented at regional, national, and international forensic science meetings and seminars. One or more papers will also be prepared for submittal to suitable, peer-reviewed forensic journals. In addition, a full in-house report of the outcomes of the project will be made available to the Minnesota BCA Forensic Laboratory and the ESR in New Zealand. Finally, a technical report on the project and its results will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Laber, T., Epstein, B., Taylor, M. "Bloodstain Formation by Common Bloodletting Mechanisms." Midwest Forensics Resource Center Annual Meeting, April 2008, Bemidji, MN.

IMPLEMENTATION

A series of video clips were prepared illustrating the formation of the main bloodstain pattern studied. The video clips are available to forensic science educators and BPA instructors through the MFRC.

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CD-ROM Based Digital Information Database on Pipe and Tubing Utilized in Improvised Explosive Devices

FORENSIC TECHNOLOGY NEED

The rise in terrorist bombings has made the identification of bomb materials a priority for forensic scientists. The volume of evidence to be analyzed and the importance of testing for preventative and investigative purposes have increased the need for tools which can aid in the identification of specific tubing material used for bombs.

Currently, available information on tubing materials and their manufacturers is either outdated or incomplete. Additionally, the data that has been gathered is either in printed format or in handwritten notes. No digital captures of this information are currently available.

TECHNOLOGY DESCRIPTION

The objectives of this project are to document:

- all known types of pipes and tubing
- worldwide pipe and tubing manufacturers
- manufacturing identification marks on pipes and tubing
- companies that import pipes and tubing into the United States
- companies that regularly stock or market each type of pipe and tubing

All of this information is placed into a searchable database containing a self-running platform (Filemaker) which does not require the user to own the software.

METHODOLOGY

The first part of the project targets documenting as many manufacturers of pipes and tubing as can be found. This is done primarily by internet searches. The next step is to contact the manufacturers to request information regarding any identification markings.

Samples of as many types as possible of pipe and tubing are purchased. This includes purchasing samples in various regions of the U.S. The samples are measured, digitally photographed and all data entered into the database.

Additionally, companies that import pipes and tubing into the U.S. are identified and documented, as well as companies that commercially sell pipes and tubing.

Figure 1. Pipe end cap made be a U.S. company.

ACCOMPLISHMENTS AND ONGOING WORK

Currently, the database contains more than 250 entries from 25 countries and consists

of the following information fields:

- Company Name
- Contact Information
- City/State
- Zip Code
- Country
- Telephone
- Fax
- Logo Description
- Type of Pipe
- Miscellaneous Information
- Website Information

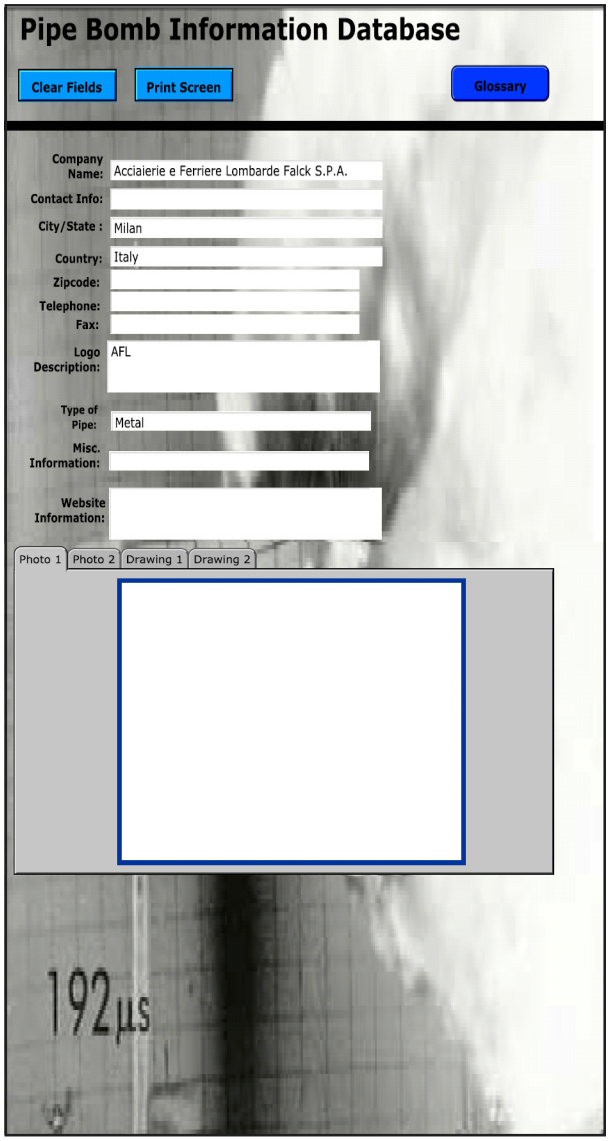

Figure 2. Pipe Bomb Database.

In addition, there are four fields for any photos that can be found or produced for the individual pipes as well as drawings of any logos or characteristic markings.

At this time, the database deals only with both steel and plastic pipe, but there are updates planned to include other types as well, such as brass and copper.

TECHNOLOGY BENEFITS

The availability of a searchable database greatly reduces the amount of time and effort that is required by forensic scientists to process bomb samples.

COLLABORATION

This project is a collaboration between the Western Law Enforcement Training Center (WFLETC), the Missouri State Highway Patrol, the Lake County Crime Laboratory, and the Midwest Forensics Resource Center (MFRC).

Personnel from the WFLETC, Lake County Regional Crime Laboratory, and the Missouri State Highway Patrol Crime Laboratory conducted internet searches and made direct contact with manufacturers, distributors, and retailers of pipe and tubing that can be used to construct pipe bombs.

The data obtained from these contacts was forwarded to the WFLETC, which purchased all samples of pipe and tubing, digitally documented the samples, and developed the database. The equipment needed to digitally document the pipe/tubing was housed at the WFLETC.

The MFRC compiled all information into a searachable CD format, and helped distribute the CDs to the forensic community.

DISSEMINATION

The product, as a beta version, was distributed to several state and federal agencies (including the FBI and TSA), at various State Department ATA courses, at forensic conferences nationwide, and at the International Association of Bomb Technicians and Investigators. A copy of the database has also been posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Crippin, J., "Pipe and Tubing Database." Presented at WFLETC explosives classes, Pueblo, CO.

- Crippin, J., "Pipe and Tubing Database." Presented at State Department post-blast investigation classes

.• Crippin, J., "Pipe and Tubing Database." Presented at American Academy of Forensic Science 59th Annual Meeting, February 2007, San Antonio, TX.

IMPLEMENTATION

The final CD-ROM product is intended for distribution nationwide to all levels of law enforcement. This includes both the investigative and forensic laboratory levels. To date, TWGFEX/NCFS and Tripwire have expressed an interest in placing the database as an online source for investigators.

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Quantification of the Individual Characteristics of the Human Dentition

FORENSIC TECHNOLOGY NEED

Daubert vs. Merrell Dow Pharmaceuticals established several factors for the admissibility of scientific evidence. One factor not available to Forensic Odontologists is the ability to scientifically quantify the occurrence of specific dental characteristics in the population. Another is the error rate in the analysis of bitemarks. Without these abilities, an Odontologist's conclusions lack a scientific basis for probability expressions and are limited to subjective opinions.

TECHNOLOGY DESCRIPTION

This project targets the development of a dataset which defines the frequency that a given set of dental characteristics occurs in the general population.

Specifically, the project aims to:

- develop a computer assisted methodology for analyzing, measuring and recording the measurement of dental characteristics
- establish a dataset of six dental characteristics which define their distribution in the general population
- investigate and calculate the probability that any two of six dental characteristics are the same
- establish the feasibility of developing a database that can be used to define the frequency a given set of dental characteristics occurs in a population

METHODOLOGY

Dental samples (n=400) are obtained randomly from clinic patients. These represent a diverse population composed of Caucasian, Black, Asian, and Hispanic males, age 18 to 44. The sample population mirrors the national population.

Exemplars are selected from the sample population, scanned as digital images, archived as read-only images and duplicated to create working files for each investigator. Using Adobe Photoshop CS2, and an automated software program developed at Marquette University, data are gathered and measurements recorded.

Recorded information includes incisor width, width of the dental arch, degree of incisor rotation, presence of diastemas (spaces), missing teeth, and accidental damage. Statistical calculations are then performed on all characteristics.

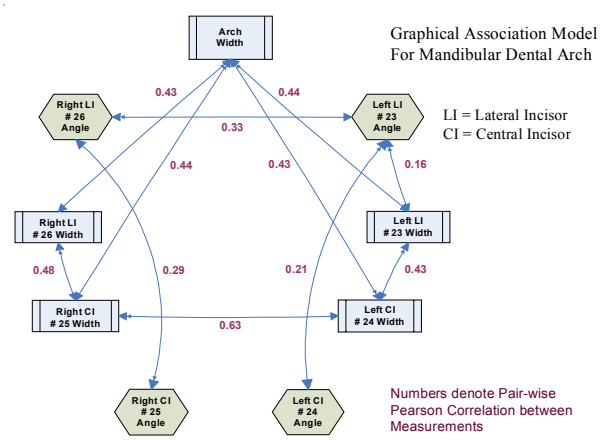

Figure 1. Graphical association model for the mandibular dental arch.

Since tooth position does not occur independently, a study is also conducted of the correlation of jaw width and tooth width on position, to determine tooth position. Pairwise Pearson Product Moment correlations are computed to describe associations between each pair of measurements.

ACCOMPLISHMENTS AND ONGOING WORK

A protocol was established to assure accuracy and repeated reliability of the scanner, computer, and software. The protocol consisted of making imprints, selecting imprints, scanning imprints as digital images, archiving the images as read-only images in .psd format, and duplicating the images as working files.

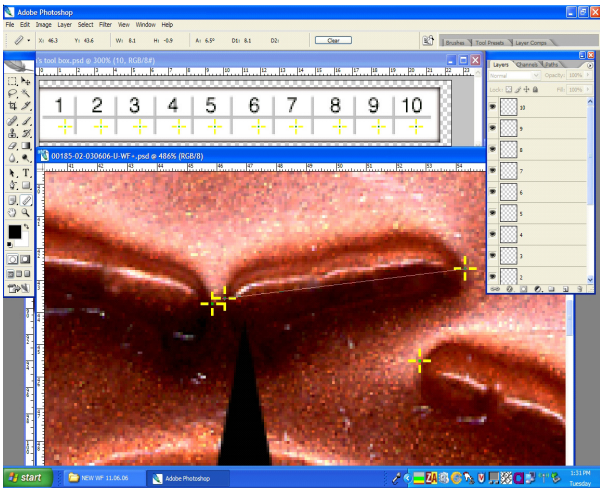

Figure 2. An automated program to read pixels which were inserted into the area to be measured. Each pixel had a different greencolor value from 1 to 250. The software recognized the distance and the degree of rotation.

Adobe Photoshop CS2, along with the automated software developed by Marquette University, were used to perform exemplar measurements. Quality control of the measurements was achieved by comparing measurements read by the automated computer software program with measurements taken manually using the measure tool in Photoshop. Final calculations were performed using SAS Statistical Analysis Software.

Research findings indicate that less than 5% of the samples have a mandibular arch width of less than 2.375 centimeters. Using the Wald-method, the 95% confidence level for the proportion of adult males having a mandibular arch width of less than 2.2 centimeters ranges from <0.1% to 2.3%. It was also found that approximately 50% of the patterns exhibited at least one outlier among the six characteristics measured. An alpha level of 0.05 was used throughout to denote statistical significance.

Collector	**Radmer**	**Johnson**
Number of Exemplars	416	410
Number of Outlying Traits	n (%)	n (%)
0	205 (49.3)	204 (49.8)
1	109 (26.2)	102 (24.9)
2	61 (14.7)	61 (14.9)
3	22 (5.3)	23 (5.6)
4	9 (2.2)	13 (3.2)

Table 1. Proportion of exemplars with outlying measurements in mandibular jaw.

The findings established statistical evidence that quantification of dental characteristics can be accomplished. Ongoing work focuses on refining and validating the data derived using the third dimension to obtain in a more discriminatory fashion the width of each individual tooth.

The protocol used in this study of dental characteristics showed potential applications for analysis of bitemarks, as well as pattern analysis in actual casework.

TECHNOLOGY BENEFITS

The ability to scientifically express the probable linkage between a human bitemark and a suspect establishes credibility and admissibility of bitemark analysis. The expansion of this data into a database reduces, if not eliminates, the reliance on opinion assessments. It also discourages the analysis of indistinct bitemark patterns, since the characteristics necessary to apply the database must be clearly observable.

COLLABORATION

The project is a collaboration between the Wisconsin Department of Justice Crime Laboratory – Milwaukee and the University of Marquette. Partnering with the Wisconsin Department of Justice Crime Laboratory provided two imaging specialists who helped set up the protocol and calibrate and test the hardware for accuracy and reliability. It also assures that the methodology conforms to the guidelines of the Scientific Working Group on Imaging Technology (SWGIT) and will be applicable to forensic analysis.

DISSEMINATION

Research findings were disseminated through various presentations and publications and have also been highlighted online (www.sciencentral.com), on TV, in several newspapers, and in two Wisconsin Department of Justice publications. A paper on the research and its findings was recently accepted for publication by the Journal of Forensic Identification. A final technical report on the project will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Johnson, L.T., Radmer, T. “Quantification of the Individual Characteristics of the Human Dentition: A Preliminary Report.” Oral presentation at the American Academy of Forensic Science, 58th Annual Meeting, February 2006, Seattle, WA.

- Johnson, L.T., Radmer, T. “Dental Science Assists Criminal Justice.” Oral presentation at the American Academy of Forensic Science, 59th Annual Meeting, February 2007, San Antonio, TX.

- Johnson, L.T., Radmer, T. “Dental Science Assists Criminal Justice.” Oral Presentation at the International Association for Identification, International Educational Conference, July 2007, San Diego, CA.

- Johnson, L.T, Radmer, T. “Quantification of the Individual Characteristics of the Human Dentition.” Poster presentation at the International Association for Identification, International Educational Conference, July 2007, San Diego, CA.

- Johnson, L.T., Wirtz, T., Radmer, T. “The Verdict is in: Can Dental Characteristics be Quantified?” Oral presentation at the American Academy of Forensics Sciences 60th Annual Meeting, February 2008, Washington, D.C.

- Johnson, L.T., “A Methodology for the Quantification of Individual Characteristics of the Human Dentition: Methodology.” Article accepted for publication in the Journal of Forensic Identification, July/August 2008.

IMPLEMENTATION

The technology was made available to three Wisconsin State Crime Laboratories for beta testing. Imaging specialists in Milwaukee, Madison, and Wausau will use the technology in the analysis of patterned injuries.

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Spectral Analysis of the 3D Fracture Surfaces for Enhanced Matching

FORENSIC TECHNOLOGY NEED

Examples of metal fragments found at a crime scene include knife tips, pieces from weapons, pry tools, or automobile parts such as antennas or trim pieces.

Physical pattern evidence using both class and individual fragment characteristics is used to link suspects to crime scenes and crime victims. Individual characteristics make objects or substances unique even among members of the same class.

There is a need for a method to measure the nature and characteristics of materials with a known error rate that can be applied to performing physical matches.

TECHNOLOGY DESCRIPTION

The overall objective of this study is to evaluate whether surface topography measurements can be used to associate metal fracture fragments. As such, it tests if the fracture feature distribution signatures for two surfaces are in fact unique. Also, that they can be relied on to determine if the two pieces sharing the fracture surface were at one time a single piece.

Specifically, the project aims to:

- develop a testing protocol to improve the power of the match by utilizing 3D topographic data of the fracture surface
- identify proper magnifications and length scales for a benchmark specimen to provide unique fracture signatures that ascertain the two pieces share the same fracture event

Figure 1. Forensic samples supplied by the collaborator for investigations

METHODOLOGY

A typical knife material (SS-440C) is used in a flexural three point bend test to determine proof-of-concept. Once proof-of-concept is established, hard plastic and glass coupons are tested in addition to metal.

The pairs of fractal surfaces are analyzed by a non-contrast 3D optical interferometer. Interferometer measurements are based on the principle that when light is reflected from two opposing surfaces, the reflected beams interferes with one another to generate interference fringes which can be used to determine the distance between two surfaces.

The collection of displacement measurements are then used to acquire surface height topographic maps from the pairs of fractal surfaces. These height topographic

maps are quantized using spectral analysis for a broken chisel fracture surface.

The first step of the analysis is to identify the number of main features on each image and their populations. For a pair of fractured surfaces the population of these features are compared via autocorrelation to provide the quality of the match.

Two main issues or challenges are addressed. 1) the proper magnification and the size of the data set to identify the proper surface topography population to identify each unique feature, 2) the directionality of the long wave length features of cracking such as river marks.

ACCOMPLISHMENTS AND ONGOING WORK

For the featured knife, a 1D analysis was conducted along lines on the sample surfaces. The spectral analysis of the data resulted in distributions for a range of spatial frequencies, giving the likelihood of feature types (river marks, grain size, dimples) on the fracture surface. The information was used to train the 2D full spectral analysis of the surface.

The collection of displacement measurements was used to acquire surface height topographic maps from the pairs of fractal surfaces for comparison. A Matlab-program was generated to read the surface height topographic maps and to perform the data quantization match analysis.

The height topographic were quantized using spectral analysis involving 2D Fast Fourier Transform algorithms to decompose the topographic height data into a finite number of frequencies. The comparison was carried out on a preselected range of these frequencies, guided by the 1D measurements.

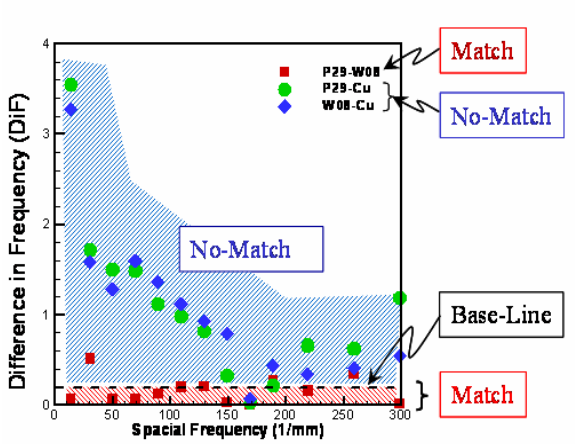

Figure 2. Measurements and analyses for two fractal surfaces showing the difference in frequency as a function of the norm frequency.

An implementation methodology was proposed to compare two fracture surfaces. The methodology consists of six steps: 1) select regions of interest and perform 3D surface topography using different magnifications; 2) calculate spectral frequencies for each surface profile; 3) divide spectra from two surfaces into zones; 4) examine the difference in frequency (DIF) as a function of the norm frequency; 5) determine the baseline for match; 6) for each image, compare the DIF relative to the baseline DIF for matching surfaces and no-match surfaces.

TECHNOLOGY BENEFITS

The study tests the core assumption that if the pattern matches, the surfaces were originally together because a fracture surface is stochastically complex and therefore unique. As such, it strengthens the scientific foundation of the fracture match practice with data to begin the task of estimating error rates.

COLLABORATION

This project is a collaborative effort between Iowa State University, Michigan

Technological University, and the Johnson County Sheriff's Crime Laboratory.

The principal investigators generated the preliminary samples and experimental data and analysis. Jeremiah Morris, from the Johnson County Sheriff's Crime Laboratory, generated simulated forensic metal fracture samples of the test materials prior to the 3D Spectral Analysis. He also collaborated on the testing protocol.

DISSEMINATION

The PIs disseminated their findings at a presentation of the International Association for Identification (IAI). A paper was also submitted for presentation at the Midwestern Association of Forensic Scientists. Currently, a manuscript is being prepared for submittal to a peer-reviewed forensic science journal. The project and its results will also be posted on the MFRC web site in the form of a final technical report.

PUBLICATIONS AND PRESENTATIONS

- Bastawros, A., Lograsso, B., Morris, J. "Spectral Analysis of the 3D Fracture Surfaces for Enhanced Matching." Poster presentation at the International Association for Identification, International Educational Conference, July 2007, San Diego, CA.

- Bastawros, A., Hui Wang, Lograsso, B., Morris, J. "Spectral Analysis of the 3D Fracture Surfaces for Enhanced Matching." Oral presentation at the 37th Annual Midwestern Association of Forensic Scientist Meeting, October 2008, Des Moines, IA.

IMPLEMENTATION

The Johnson County Sheriff's Crime Laboratory is critically assessing implementation of the test methodology.

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A Method for Lifting Bloody Impressions Using a Lifting Strip Containing Titanium Dioxide

FORENSIC TECHNOLOGY NEED

Bloody impressions are of great importance to the forensic science community as they are frequently encountered at crime scenes and on evidence submitted to the laboratory for analysis. A variety of techniques are currently available for enhancing bloody fingerprints on some non-porous, semi-porous and porous surfaces.

Yet, these require different enhancement processes depending on the surface porosity and background color. In addition, many of the processes require using toxic chemical reagents and need to be conducted in a laboratory setting. Since impression evidence in blood cannot always be removed from the crime scene for analysis in a laboratory setting, many potentially identifiable impressions can only be photographed and not enhanced.

TECHNOLOGY DESCRIPTION

In an earlier study, a lifting strip containing titanium dioxide was successful in lifting and enhancing bloody fingerprints from several nonporous and semi-porous surfaces of contrasting colors. The lifting strips worked best when activated with a surfactant. After drying, the strip could easily be removed from the surface, lifting the bloody fingerprint onto a contrasting white background for examination.

METHODOLOGY

The primary objective of this study is to improve upon methods used in the initial research by utilizing the lifting strip containing titanium dioxide to lift bloody fingerprints, palm prints, foot prints, and footwear impressions.

To achieve this, the study will incorporate experiments on

- pure proteinaceous blood samples and blood samples of diluted proteinaceous material with water
- a larger variety of non-porous, semi-porous, and porous surfaces, including glass, drywall, wood, ceramic tile, and linoleum
- aged impressions
- larger lifting strips conducive to lifting bloody palm prints, foot prints, and footwear impressions
- application of the lifting strip
- new reagents, including methanol and water, Kodak Photo-Flo 200 with water, Citron detergent with water, and a combination of Kodak-Flo 200 with Citron detergent and water
- air drying lifting strips after activation
- fingerprint enhancement techniques
- presumptive DNA testing on lifted impressions to determine if DNA is destroyed during the lifting process

ACCOMPLISHMENTS AND ONGOING WORK

This is a new project that has not started work yet.

TECHNOLOGY BENEFITS

Immovable objects from crime scenes cannot be brought back to the laboratory for analysis. Because of this, many potentially identifiable impressions may only be photographed and not enhanced thereby complicating the latent print identification process. With the use of the new uniform lifting strip, these problems can be alleviated while still providing optimal quality impressions for analysis.

COLLABORATION

This is a collaborative effort between the Northville Policy Department and the Latent Print, DNA, and Trace units of the Michigan State Police Northville Forensic Science Laboratory.

DISSEMINATION

The results of this study will be disseminated through presentations at forensic science conferences and at trade shows for the law enforcement community. Research findings will also be published in forensic journals and as a technical report posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

This is a new research project with no publications or presentations to date.

IMPLEMENTATION

Upon completion of the research, the Michigan State Police Northville Crime Laboratory plans to field test the lifting strip with intent to incorporate this method into department policies and procedures state-wide. The analyst is also working with the Lynn Peavy Company to discuss manufacturing the product. If manufactured, the product will be marketed to law enforcement agencies nationwide through forensic catalogs and web sites.

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Testing for Potential Contextual Bias during the Verification Stage of the ACE-V Methodology when Conducting Latent Print Examinations

FORENSIC TECHNOLOGY NEED

Recent Daubert challenges to fingerprint evidence and the Analysis, Comparison, Evaluation, and Verification (ACE-V) methodology have questioned the reliability of ACE-V methodology as it is currently applied by experts. Until recently, no research had been conducted to test the effects of potentially biasing context information upon fingerprint experts. A recent study performed by a group in England suggests that experts are biased by context information. However, concerns have been raised about the study design, limited number of participants, and the lack of control group. This study explores how expert opinion varies under different experimental conditions.

TECHNOLOGY DESCRIPTION

Objectives of the project are to investigate potential contextual bias during the verification stage of ACE-V. When verifying the conclusions of a latent print examiner, the verifier typically knows the conclusions of the initial examiner. A primary question that needs to be answered is: does this prior knowledge alone influence the verifier's conclusion? A secondary question is: does the identity and reputation of the initial examiner, coupled with prior knowledge of their conclusion, influence the verifier's conclusion.

METHODOLOGY

These questions were answered through a controlled experiment with experts and non-experts. Experiments involving experts were conducted at the International Association for Identification (IAI) Annual Educational Conference in Boston, MA. Experiments with non-experts were conducted at a local community college. The principal investigator (PI) instructs an introductory forensic science course, and during three semesters, a class of about 30 students participated in the non-expert experiments.

Each set of expert and non-expert participants was divided randomly into three groups. Each group was given a set of six latent fingerprints for which they were instructed to report two variables for measurement. The first variable was the conclusion. The second variable was the amount of information used to reach the conclusion. Statistical analyses were performed on the data collected.

The materials for each group consisted of a series of latent print comparisons of varying difficulty. The latent prints and known exemplars for comparison were derived from a sample of prints whose sources were known to the researchers.

The expert portion of the experiment was conducted at the IAI conference in Boston, MA, July 2-7, 2006. Forty-three volunteers participated, randomly divided into three separate groups.

Group A received a series of six latent print comparisons for which they were instructed to provide an expert opinion. This was the control group: no contextual information was provided. Group B was given the same six comparisons as the first group, but this time provided with a conclusion that was said to have been reported by an unnamed expert. Group C was given the same six comparisons as the previous two groups, but was presented with conclusions by Pat

Wertheim, an internationally recognized expert.

The same protocol was followed in experiments involving non-experts. The experiment with Group B participants (low bias) was conducted in May 2006, while Group C (high bias) and Group A (control) experiments were conducted in September 2007, and January 2007, respectively. During these experiments data were collected and entered into a database. Statistical analyses on the data were performed at the University of Lausanne, Switzerland.

ACCOMPLISHMENTS AND ONGOING WORK

Results showed that fingerprint experts were influenced by contextual information during fingerprints comparisons, but not towards making errors. Instead, fingerprint experts under the biasing conditions provided significantly fewer definitive and erroneous conclusions than the control group. They tended to provide opinions that were inconclusive.

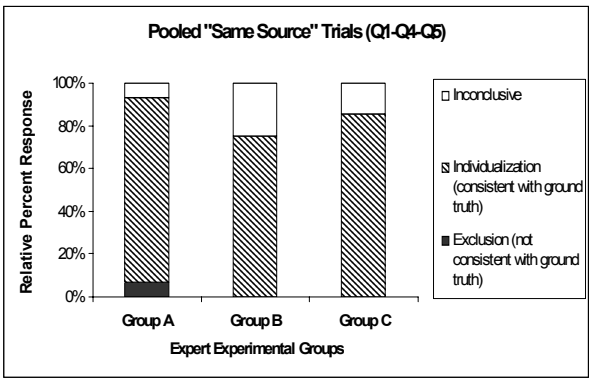

Figure 1. Pooled expert trials assessing images from the same source.

Novice participants were more influenced by the bias conditions and did tend to make incorrect judgments, especially when prompted towards an incorrect response by the bias prompt. This was not the case with the fingerprint experts.

Experience (in terms of years of experience in fingerprint examination) was not shown to be a significant factor for specialists when assessing images from the same source, but was a factor when assessing images from different sources.

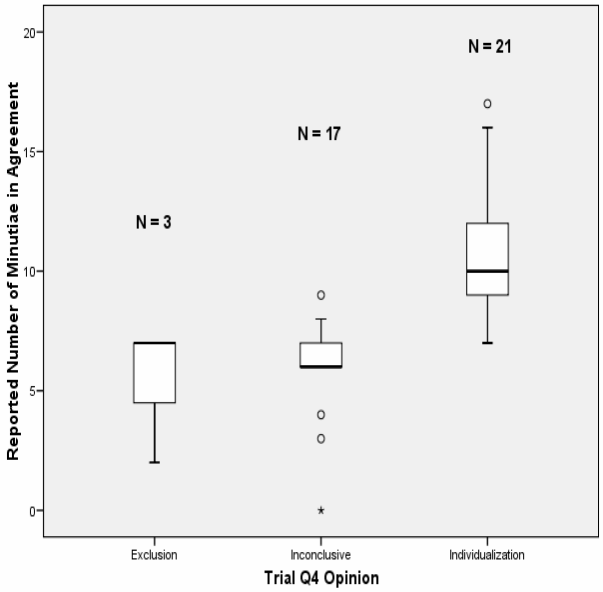

Figure 2. Trail Q4 Opinion vs. the number of corresponding minutiae reported by the expert.

Significant variation was observed for fingerprint experts when asked to count the number of minutiae in agreement for trials where the images originated from the same source. The number of minutiae in agreement as reported by the specialist was a significant factor in claiming the images to be a definitive match.

TECHNOLOGY BENEFITS

The results of this experiment provides valuable insight on the effects of potentially biasing context information when present during the verification of latent print examinations. Strong critical voices have called for a complete overhauling of the identification

methodology but presently there is limited research evidence to support this.

The major recommendation that has emerged is to use a blind testing scheme for difficult examinations, particularly those resulting in an exclusion. Also, when examiners are placed in an "alert" state, they tend to become more conservative. Therefore, quality control schemes which achieve this "alert" state, such as selection of cases for audits and random checks, are also encouraged.

COLLABORATION

This project is a collaboration between the Minnesota Bureau of Criminal Apprehension (BCA), the University of Lausanne Switzerland (UNIL), and the Arizona Department of Public Safety Crime Laboratory.

PI Glenn Langenburg is currently a Certified Latent Print Examiner at the BCA. He is also a candidate in forensic science at UNIL. This project represents a portion of his thesis work towards completion of the Ph.D.

DISSEMINATION

The results of this study were presented at several national and international meetings, conferences, and symposia. Results of the research were also presented at UNIL as part of a thesis defense. A paper on the research and its findings was accepted for publication in the Journal of Forensic Sciences. A copy of the final technical report on the project and its findings will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

- Langenburg, G. "Testing for the Potential Effects of Contextual Bias during the Verification Stage of the Latent Fingerprint Comparisons." International Fingerprint Research Group Symposium, March 2007, Canberra, Australia.

- Langenburg, G., "Experiments with the ACE-V Process of Fingermark Comparisons-including a Contextual Bias Study during the Verification Stage," 30th Anniversary of the Canadian Identification Society, July 2007, Montreal, Canada.

- Langenburg, G., Champod, C., Wertheim, P. "Testing for Potential Contextual Bias during the Verification Stage of the ACE-V Methodology when Conducting Latent Print Examinations." Presentation at the International Association for Identification, International Education Conference, July 2007, San Diego, CA.

- Langenburg, G., "Fingerprint Issues for Latent Examiners." 42nd Wisconsin Association for Identification, Educational Conference, March 2008, Wauwatosa, WI.

- Langenburg, G., "Testing for Potential Contextual Bias during the Verification Stage of the ACE-V Methodology when Conducting Latent Print Examinations." Midwest Forensics Resource Center Annual Meeting, April 2008, Bemidji, MN.

- Langenburg, G., Dror, I., and Srihari, S. "Whose Print Is It Really: Does Confirmation Affect the Answer?" National Institute of Justice Conference, July 2008, Arlington, VA.

- Langenburg, G., Champod, C., Wertheim, P. "Testing for Potential Contextual Bias Effects During the Verification Stage of the ACE-V

Methodology when Conducting Fingerprint Comparisons." Paper accepted for publication in the Journal of Forensic Sciences, May 2009.

IMPLEMENTATION

The Minnesota BCA is currently writing SOPs that reflect some of the recommendations made. Research findings and recommendations were also incorporated in the course "Advanced ACE-V Applications for Latent Print Examiners".

The Hennepin County Sheriff's Office, New York State Police, and Los Angeles Police and Sheriff's Departments have all requested copies of the SOPs to consider during their policy drafting.

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Testing DNA Samples for Population of Origin

FORENSIC TECHNOLOGY NEED

A large portion of annual DNA criminal cases are “unsub cases” with completely unknown information about the perpetrator. For these the crime laboratory can provide Combined DNA Index System (CODIS) DNA profiles.

If the profile is not in the database, the DNA information does not provide immediate assistance to field investigators. For such cases, a forensic technique called “population test” can be used.

TECHNOLOGY DESCRIPTION

The “population test” uses available equipment to provide information about the population of origin of the DNA sample contributor. The biological basis for the test resides in frequency patterns of a few single nucleotide polymorphisms (SNPs).

For most SNPs, allele frequencies among diverse populations are similar. However, for a small fraction of SNPs, they are quite divergent. A collection of the most extreme of these allele frequencies, called ancestral informative markers (AIMs), has been identified and characterized in nine populations.

METHODOLOGY

Specific aims of this project are to:

- identify a subset of AIMs that will be sufficiently powerful for the population test
- assemble components of the population test, including chemistry and analysis tools, and validate them by characterizing additional sets of DNAs
- assist collaborators in implementing the population test by providing components, protocols, and technical advice
- publicize the population test to the wider forensic science community

ACCOMPLISHMENTS AND ONGOING WORK

A set of sixteen AIMs was identified for use in the population test. They were selected based on: TagMan assay availability, NCBI/dbSNP database identification, international HapMap project genotyping, autosomal distribution in the genome; and high frequency divergence between two or more populations of different continental origin.

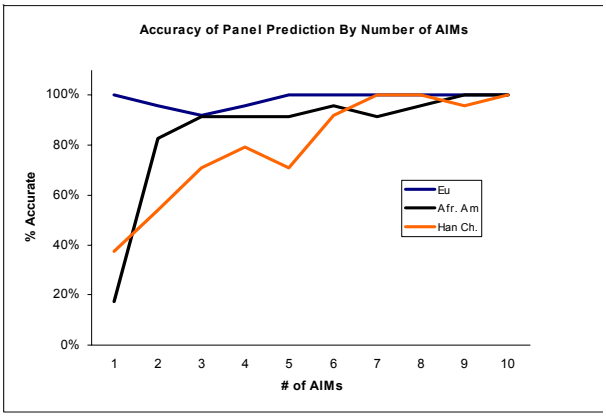

Figure 1. Number of AIMs required.

Extensive *in silico* simulations were performed on the sixteen AIMs to establish the theoretical framework for the population test. On the appropriate scale, each of 1000 simulated individuals from a European-derived population (EUA) could be clearly excluded from African (AFR), East Asian (EAS), American Indian (AMI), and from African American populations.

However, they could not always be excluded from the South Asian (SAS) population or from the Puerto Rican population. Also, the test did not tell which population the sample came from. Yet it could exclude many populations (particularly those of different continental origin) as the source of the sample.

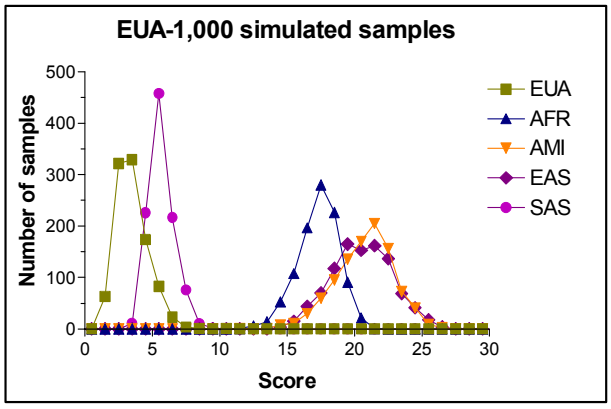

Figure 2. Population test results for 1000 simulated European-derived samples.

The HapMap project database was mined to confirm how the population test would perform on humans of known population origin. Genotypes were obtained for the selected AIMs in the 90 CEPH trios of European descent, 90 Yoruba trios from Nigeria, 45 unrelated Han Chinese from Beijing, and 45 unrelated Japanese from Tokyo.

For each of the individuals except one, populations of origin on different continents were excluded. For the exception, many of the genotypes were missing, demonstrating one complexity of actual data sets. With missing data, the population test is conservative, possibly failing to exclude some populations.

TagMan reagents were assembled and tested, confirming the same genotypes as the HagMan project. Previously, TagMan genotyping has been used to analyze a few SNPs for many DNA samples. To make the test more efficient, technology was developed to analyze 16 SNPs/AIMs for 1- 6 DNA samples in one regiment. The software for this process was developed as well as the software to calculate how likely a genotyped sample is from any of the nine reference populations.

TECHNOLOGY BENEFITS

The test used equipment available in most forensic laboratories to provide information about the DNA sample contributor's ancestry. Although the test could not tell which population the sample came from, it could exclude populations of different continental origin as the source of the sample.

COLLABORATION

This project is a collaborative effort between the School of Medicine at Washington University, the Missouri State Highway Patrol Crime Laboratory, the St. Louis County Crime Laboratory, and the St. Charles County Crime Laboratory.

DISSEMINATION

A publication on the research and its findings is in preparation. A final technical report on the project and the project's findings will be posted on the MFRC web site.

PUBLICATIONS AND PRESENTATIONS

This work was briefly described in a news and opinion feature article in BioScience, "Crime Scene Genetics: Transforming Forensic Science through Molecular Technologies.", Volume 58, Issue 6 (484-489).

Protocols, training materials, the list of AIMs, and data generated as part of the project are available online (http://snp.wustl.edu).

IMPLEMENTATION

Discussions are being held with the three collaborators to implement the test at their crime laboratories.

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